

FINAL SUBMITTAL

## VOLUME II

## APPENDICES

# ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS FT. SILL, OKLAHOMA

Prepared for

**TULSA DISTRICT  
CORPS OF ENGINEERS  
TULSA, OKLAHOMA**

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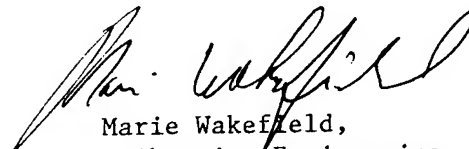


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## LIST OF ABBREVIATIONS

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ac	-	alternating current
ACCU	-	air cooled condensing unit
AEL	-	acceptable exposure limit
AHU	-	air handling unit(s)
amp	-	ampere (amp, amps)
ANSI	-	American National Standards Institute
ASCII	-	American Standard Code for Information Interchange
ASHRAE	-	American Society of Heating, Refrigeration, and Air Conditioning Engineers
AWG	-	American wire gauge
bar	-	bar: 14.5 psi
BAU	-	business as usual
B/C	-	benefit-to-cost ratio
Bhp	-	brake horsepower
Bks	-	barracks
BLAST	-	Building Loads Analysis and System Thermodynamics Program, CERL
Bldg	-	building
BOQ	-	Bachelor Officer's Quarters
Btu	-	British thermal units
Btuh	-	British thermal units per hour
B/W	-	black and white
°C	-	Celsius (Centigrade)(degrees)
cc	-	cubic centimeter

## LIST OF ABBREVIATIONS (Continued)

---

ccf	-	one hundred (100) cubic feet
CEP	-	central energy plant
CFC	-	chlorofluorocarbons
cfh	-	cubic feet per hour
cfm	-	cubic feet per minute
ckVAR	-	capacitive kilovolt-ampere reactive
CNW	-	condensed water
CNWP	-	condensed water pump
CNWR	-	condensed water return
CNWS	-	condensed water supply
CO	-	carbon monoxide
COND.	-	condenser
const	-	construction
COP	-	coefficient of performance: ratio of the tons of refrigeration produced to the energy required to operate the equipment
CO <sub>2</sub>	-	carbon dioxide
CPU	-	central processing unit
CY	-	current transducer
CTD	-	Carnahan-Thompson-Delano
CTM	-	cooling tower motor
cu ft	-	cubic foot, cubic feet
CW	-	chilled water

## LIST OF ABBREVIATIONS (Continued)

---

CWE	-	current working estimate
CWP	-	chilled water pump
CWR	-	chilled water return
CWS	-	chilled water supply
CV	-	converter
d	-	day(s)
DB	-	dry bulb
DD	-	Degree Day: the difference between the median temperature for any hour and a selected base temperature (generally 65°F)
deg	-	degrees
DEH	-	Director of Engineering and Housing
DHW	-	domestic hot water
Di	-	inside diameter
DOM.	-	domestic
DP	-	differential pressure transducer
DX	-	direct expansion
E <sub>b</sub>	-	boiler efficiency
E/C	-	energy-to-cost ratio
ECIP	-	Energy Conservation Investment Program
ECO	-	energy conservation opportunity(s)
EEAP	-	Energy Engineering Analysis Program
eff	-	efficiency

## LIST OF ABBREVIATIONS (Continued)

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EIC	-	Engineer In Charge
elec	-	electrical
E <sub>m</sub>	-	motor efficiency
EMC	-	E M C Engineers, Inc.
EMCS	-	Energy Monitoring and Control System
EPA	-	Environmental Protection Agency
eqpt	-	equipment
F	-	flow meter
°F	-	Fahrenheit (degrees)
FLA	-	full load amps
ft	-	foot, feet
ft <sup>2</sup>	-	square feet
ft <sup>3</sup>	-	cubic feet
FO	-	fuel oil
gal	-	gallon(s)
g/dscm	-	grams per dry standard cubic meter
gpm	-	gallons per minute
HCFC	-	hydrochlorofluorocarbon
HCP	-	hot/chilled water pump
HCR	-	hot/chilled water return
HCS	-	hot/chilled water supply
HCW	-	hot/chilled water

## LIST OF ABBREVIATIONS (Continued)

---

HG	-	mercury
hp	-	horsepower
hr	-	hour(s)
HTHW	-	high temperature hot water
H&V	-	heating and ventilating
HVAC	-	heating, ventilating, and air conditioning
HW	-	hot water
HWR	-	hot water return
HWS	-	hot water supply
Hz	-	hertz, frequency
in	-	inch(es)
I/O	-	input/output
°K	-	kelvin (degrees)
kip	-	one thousand pounds
kW	-	kilowatt, one thousand watts
kWh	-	kilowatt-hour, one thousand watthours
kV	-	kilovolt, one thousand volts
kVAh	-	kilovolt-ampere hour, one thousand volt-ampere hour(s)
kVAR	-	kilovolt-ampere reactive
kVARh	-	kilovolt-ampere reactive hour, one thousand volt-ampere reactive hour(s)
L	-	length

## LIST OF ABBREVIATIONS (Continued)

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lb	-	pound(s)
LCC	-	life cycle cost
LCCID	-	life cycle cost in design
LTHW	-	low temperature hot water
m	-	meter
m <sup>3</sup>	-	cubic meters
maint	-	maintenance
Mbh	-	Btu per hour (thousand)
mcf	-	one thousand cubic feet
MCP	-	Military Construction Program
Mh	-	man-hour(s)
mm	-	millimeter
MMBtu	-	British thermal units (million)
MMBtuh	-	Btus per hour (million)
mo.	-	month(s)
MUX	-	multiplexer
mW	-	megawatt, one million watts
mWh	-	megawatt-hour, one million watt-hours
MZU	-	multizone unit
N/A	-	not available or not applicable
nat	-	natural (gas)
NBS	-	National Bureau of Standards

## LIST OF ABBREVIATIONS (Continued)

---

NOAA	-	National Oceanic and Atmospheric Administration
no.	-	number
O <sub>2</sub>	-	oxygen
OA	-	outside air
O & M	-	operation and maintenance
PD	-	pressure drop or difference
PLT	-	plant
PF	-	power factor: relationship between kW and kVA. When the power factor is unity, kVA equals kW.
PM	-	Project Manager
ppm	-	parts per million
psi(a)(g)	-	pounds per square inch (absolute)(gauge)
Q	-	flow rate
R	-	return
RDF	-	refuse derived fuel
RET.	-	return
RVAC	-	refrigeration, ventilation, air conditioning
R-value	-	the resistance to heat flow expressed in units of (ft <sup>2</sup> ) x (hours) x (°F)/Btu; R-value = 1/U-value
S	-	supply
scf	-	standard cubic feet
scfm	-	standard cubic feet per minute

## LIST OF ABBREVIATIONS (Continued)

---

SIR	-	Savings-to-Investment Ratio: total life cycle benefits divided by 90% of the differential investment cost
SIOH or SIA	-	supervision, inspection, and overhead
SOW	-	scope of work
sq ft	-	square foot (feet)
st/sp	-	start/stop
SWPA	-	Southwestern Power Administration
SZU	-	single zone unit
stby	-	standby
t	-	ton, a means of expressing cooling capacity: 1 ton - 12,000 Btu/hr cooling
T	-	temperature
temp	-	temperature
TD	-	temperature difference
$T_f$	-	fluid temperature ( $^{\circ}\text{C}$ )
$T_g$	-	ground temperature ( $^{\circ}\text{C}$ )
TPF	-	third party financing
TRY	-	Test Reference Year
UA	-	overall heat transfer coefficient (Btu/hr- $^{\circ}\text{F}$ )
UPW	-	uniform present worth factor: a factor which, when applied to annual savings, will account for the time value of money and inflation over the life of the project
U.S.	-	United States

## LIST OF ABBREVIATIONS (Continued)

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U-value	-	a coefficient expressing the thermal conductance of a composite structure in Btu per (sq ft)(hour)(°F temperature difference); $\text{Btu/ft}^2 \times \text{hr} \times ^\circ\text{F}$ ; $\text{U-value} = 1/\text{R-value}$
V	-	volt(s)
VAT	-	value added tax
VAV	-	variable air volume
VSD	-	variable speed drive
W	-	watt(s)
WB	-	wet-bulb
wk	-	week(s)
yr	-	year(s)

**APPENDIX A**

**SCOPE OF WORK**

**SCOPE OF WORK SUMMARY**  
**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS, Fort SILL, OKLAHOMA**

ITEM NO.	SOW PAGE	SOW SECTION	DESCRIPTION	REPORT SECTION
1	1	1.1	Survey the boilers to determine their efficiency.	2.0
2	1	1.3	Identify and list all ECOs considered.	4.0
3	1	1.3	Identify low cost or no cost ECOs.	6.0
4	1	1.6	Prepare report.	-
5	1	2.1	Include in the study the results of previous studies concerning boiler and chiller plants.	5.0
6	2	2.5	Determine if ECOs are technically and economically feasible.	4.0
7	2	2.5	Combine ECOs into larger packages for ECIP or MCP funding.	8.0
8	2	2.6	List and prioritize, by SIR, projects which qualify for ECIP funding.	Table 7-2
9	2	2.7	Prioritize, by SIR, feasible non-ECIP projects.	8.0
10	4	5.1	Develop life cycle cost analysis summary sheets for ECIP projects.	Appendix D
11	4	5.1	Provide original backup calculations from previous studies.	Appendix G and H
12	5	5.2	Develop life cycle cost analysis summary sheets for non-ECIP projects.	Appendix D
13	6	5.3	Document nonfeasible ECOs in the report.	4.0
14	6	7.1.1	Conduct boiler efficiency tests.	Appendix F, Survey Notes
15	6	7.1.2	Conduct chiller efficiency tests.	Appendix E, Survey Notes
16	7	7.2.2	Investigate existing local controls and incorporate into EMCS.	4.0
17	7	7.2.3	Review, document, and evaluate operation and maintenance practices.	2.0 and 6.0

**SCOPE OF WORK SUMMARY (Concluded)**  
**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS, Fort SILL, OKLAHOMA**

ITEM NO.	SOW PAGE	SOW SECTION	DESCRIPTION	REPORT SECTION
18	7	7.3	Thoroughly evaluate and document all potential ECOs which are not eliminated.	Appendix D
19	8	7.6	Prepare a comprehensive report.	Interim Submittal
20	10	7.6.1	Interim submittal - include analyses performed to date and results of field survey.	Interim Submittal
21	10	7.6.1	Interim submittal - include copies of the Scope of Work and any modifications.	Appendix A
22	10	7.6.1	Interim submittal - provide a narrative summary.	Executive Summary
23	10	7.6.1	Interim submittal - include copies of field survey forms.	Appendix E and F
24	10	7.6.2	Prefinal submittal - document the integrated aspects of the study.	8.0
25	10	7.6.2	Prefinal submittal - include an order of priority, by SIR, for the recommended ECOs.	8.0
26	11	7.6.2	Prefinal submittal - include an executive summary per Annex D.	Executive Summary
27	11	7.6.2	Prefinal submittal - list all projects and ECOs developed in the study.	7.0 and 8.0
28	11	7.6.3	Final Report - incorporate revisions and corrections resulting from comments.	Final Report
29	11	8.2	Identify operational items noted in the study which will effect energy conservation.	Section 6.0
30	6	7.1.1 & 7.1.2	Use metering equipment with the proper accuracies and calibration.	Appendix E
31	A-17	-	Present overview of the impact on changing refrigerants to environmentally safe refrigerants.	Section 5.0
32	-	-	Plants included in study: 730, 914, 2812, 4701, 5676, 5678, 5900, 6003.	-

**SCOPE OF WORK SUMMARY, ECOs EVALUATED**  
**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS, Fort SILL, OKLAHOMA**

ECO DESCRIPTION IN SOW	SOW LOCATION	ECO NO.	ECO DESCRIPTION IN REPORT
Controls to assure proper combustion air-fuel ratio.	Annex A	10	Installation of combustion controls.
Installation of new burner equipment.	Annex A	11	Installation of new high efficiency burner.
Economizer or air preheater.	Annex A	12	Installation of stack economizer or air preheater.
Loading characteristics and scheduling versus equipment capacity (equipment optimization).	Annex A	2 & 8	2 - Chiller optimization. 8 - Boiler optimization.
Control systems to operate chillers at the most energy efficient operating condition.	Annex A	2	Chiller optimization.
Variable or two-speed cooling tower fan.	Annex A	5(A) & 5(B)	5(A) Two-speed motors. 5(B) Variable speed control.
Storage of chilled water or other thermal storage systems.	Annex A & Conf. Notice 1	4	Ice storage cooling system.
High efficiency motors.	Annex A	6	High efficiency motors.
Instruments and controls to facilitate efficient operations.	Annex A	1 & 7	1 - Chiller instruments. 7 - Boiler instruments.
Use smaller boilers where load has been reduced.	Annex A	8	Boiler optimization.
Replace inefficient boilers with more efficient boilers (or repair).	Annex A (para 7.2.1)	9	Renovate or replace boilers.
Replace inefficient chillers with more efficient chillers (or repair).	Annex A (para 7.2.1)	3	Renovate or replace chillers.

Appendix A

GENERAL SCOPE OF WORK

FOR AN

ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS

FOR

FORT SILL, OKLAHOMA

Performed as part of the

ENERGY ENGINEERING ANALYSIS PROGRAM

Exhibit 1

1. BRIEF DESCRIPTION OF WORK: The Architect-Engineer (AE) shall:

1.1 Determine the efficiency of the boiler/chiller plants by appropriate tests.

1.2 Survey the boiler/chiller plants to determine if efficiency can be improved by the repair, addition, or modification of equipment, control systems and operation and maintenance practices and recommend improvements.

1.3 Identify all energy conservation opportunities (ECOs) including low cost/no cost items and perform complete evaluations of each.

1.4 (Deleted)

1.5 (Deleted)

1.6 Prepare a comprehensive report to document the work performed, the results and recommendations.

2. GENERAL

2.1 Other studies performed under the Energy Engineering Analysis Program (EEAP) have been performed at the installation and may have included the boiler/chiller plants. Results of the previous studies concerning the boiler/chiller plants shall be included in this study. Boiler/chiller plant projects recommended in the previous studies shall be updated and included in this report if they have not been implemented or programmed. Any reports or studies that may have been accomplished on the boiler/chiller plants shall be reviewed by the AE and information included in this report as applicable.

2.2 The information and analysis outlined herein are considered to be minimum essentials for adequate performance of this study.

2.3 This study shall include the boiler plant, chiller plant, all appurtenances, and supporting systems (e.g., fuel storage facilities, pollution abatement, water treatment, etc.). It does not include steam or chilled water distribution systems. However, if during the survey readily identifiable energy conservation opportunities pertaining to the distribution systems are noted, they shall be listed in the report.

2.4 The "Energy Conservation Investment Program (ECIP) Guidance," described in letter from CEHSC-FU, dated 25 April 1988, and revised in letter from CEHSC-FU-P, dated 15 June 1989, establishes criteria for ECIP projects and shall be used for performing the economic analysis of all projects or improvements considered.

2.5 Energy conservation opportunities determined to be technically and economically feasible shall be developed into projects acceptable to installation personnel. This may involve combining similar ECOs into larger packages which will qualify for ECIP or MCA funding, and determining, in coordination with installation personnel, the appropriate packaging and implementation approach for all feasible ECOs. Energy conservation opportunities which do not fit into projects, such as operation procedure changes, shall be developed into detailed and specific instructions and procedures for operating personnel.

2.6 Projects which qualify for ECIP funding shall be identified, separately listed, and prioritized by the Savings to Investment Ratio (SIR).

2.7 All feasible non-ECIP projects shall be ranked in order of highest to lowest SIR.

2.8 Energy Conservation and Management (ECAM) projects for procurement-funded installations will be identified and analyzed using the same criteria as for ECIP. ECAM and ECIP will be considered synonymous in this Scope of Work.

### 3. PROJECT MANAGEMENT

3.1 Project Managers. The AE shall designate a project manager to serve as a point of contact and liaison for all work required under this contract. Upon the award of the contract, this individual shall be immediately designated in writing. The AE's designated project manager must be approved by the Contracting Officer prior to commencement of work. This designated individual shall be responsible for complete coordination of work required under this contract. The Contracting Officer will designate a project manager to serve as the Government's point of contact and liaison for all work required under this contract. This individual will be the Government's representative.

3.2 Installation Assistance. A coordinator designated by the Commanding Officer at each installation will serve as the point of contact for obtaining available information and assist-

ing in establishing contacts with the proper individuals and organizations as necessary to accomplish the work required under this contract.

**3.3 Public Disclosures.** The AE shall make no public announcements or disclosures relative to information contained or developed under this contract, except as authorized by the Contracting Officer.

**3.4 Meetings.** Meetings will be scheduled whenever requested by the AE or the Contracting Officer for the resolution of questions or problems encountered in the performance of the work. The AE and/or the designated representative(s) shall be required to attend and participate in all meetings pertinent to the work required under this contract as directed by the Contracting Officer. These meetings, if necessary, are in addition to the presentation and review conferences.

**3.5 Site Visits, Inspections, and Investigations.** The AE, consultants, if applicable, and/or designated representative(s) thereof shall visit and inspect/investigate the site of the project as necessary and required during the preparation and accomplishment of the work.

### **3.6 Records**

**3.6.1** The AE shall provide a record of all significant conferences, meetings, discussions, verbal directions, telephone conversations, etc., with Government representative(s) relative to this contract in which the AE and/or designated representative(s) thereof participated. These records shall be dated and shall identify the contract number, and modification number, if applicable, participating personnel, subject discussed and conclusions reached. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the records.

**3.6.2** The AE shall provide a record of requests for and/or receipt of Government-furnished material, supplies, data, documents, information, etc., which if not furnished in a timely manner, would significantly impair the normal progression of work under this contract. The record shall be dated and shall identify the contract number and modification number, if applicable. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the record of request or receipt of material.

**3.7 Interviews.** The AE and the Government's representative shall conduct entry and exit interviews with the Director of Engineering and Housing before starting work at the facility and after completion of the field work. The Government's representative shall schedule the interviews at least one week in advance.

3.7.1 Entry. The entry interview shall thoroughly brief and describe the intended procedures for the survey and shall be conducted prior to commencing work at the facility. As a minimum, the interview shall cover the following points:

- a. Schedules.
- b. Names of energy analysts who will be conducting the survey.
- c. Proposed working hours.
- d. Support requirements from the Director of Engineering and Housing.

3.7.2 Exit. The exit interview shall include a thorough briefing describing the items surveyed and probable areas of energy conservation. The interview shall also solicit input and advice from the Director of Engineering and Housing.

4. SERVICES AND MATERIALS. All services, supplies, materials (except those specifically enumerated to be furnished by the Government), plant, labor, testing equipment, superintendence and travel necessary to perform the work and render the data required under this contract shall be included in the lump sum price of the contract.

PROJECT DOCUMENTATION. All energy conservation opportunities which the AE has considered shall be included in one of the following categories and presented as such in the report:

5.1 ECIP Projects. To qualify as an ECIP project, an ECO, or several ECOs which have been combined, must have a construction cost estimate greater than \$200,000, a Savings to Investment Ratio greater than one and a simple payback period of less than eight years. For ECAM projects the \$200,000 limitation may not apply. The AE shall check with the installation for guidance. The overall project and each discrete part of the project shall have a SIR greater than one.

A Life Cycle Cost Analysis Summary Sheet shall be developed for each ECO and for the overall project when more than one ECO is combined. For projects and ECOs updated or developed from the previous studies, the backup data shall consist of copies of the original calculations and analysis, with new pages revising the original calculations and analysis. In addition, the backup data shall include as much of the following as is available: the increment of work the project or ECO was

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developed under in the previous study, title(s) of the project(s), the energy to cost (E/C) ratio, the benefit to cost (B/C) ratio, the current working estimate (CWE), and the payback period. This information shall be included as part of the backup data. The purpose of this information is to provide a means to prevent duplication of projects in any future reports.

5.2 Non-ECIP Projects. Projects which normally do not meet ECIP criteria, but which have an overall SIR greater than one shall be individually packaged and fully documented. The Life Cycle Cost Analysis Summary Sheet shall be completed through and including line 6 for all projects or ECOs. Each shall be analyzed to determine if they are feasible even if they do not meet ECIP criteria. These ECOs or projects may not meet the nonenergy qualification test. For projects or ECOs which meet this criteria, the Life Cycle Cost Analysis Summary Sheet, completely filled out, with all the necessary backup data to verify the numbers presented, a complete description of the project and the simple payback period shall be included in the report. ;

5.3 Nonfeasible ECOs. All ECOs which the AE has considered but which are not feasible, shall be documented in the report with the reasons and justifications showing why they were rejected.

6. DETAILED SCOPE OF WORK: The general Scope of Work is intended to apply to contract efforts for all Army boiler and chiller plants except as modified by the detailed Scope of Work for each specific installation. The detailed Scope of Work is contained in Annex B.

## 7. WORK TO BE ACCOMPLISHED

### 7.1 Determine Efficiency

7.1.1 Boilers. The efficiency of the existing boiler installation shall be determined by field testing. The AE shall provide equipment and perform tests in the field to establish the efficiency of the boilers. The tests are intended to determine the efficiency of the boilers as they are actually being operated. The AE shall document any changes made to controls or equipment during boiler efficiency tests.

The AE shall submit the proposed test procedure and testing laboratory to the Contracting Officer for approval. Based upon the results of the tests, any indicated areas of improvement or equipment modification shall be fully analyzed. The study shall establish equipment operating data baselines, system efficiency modeling, and evaluate plant and unit loading profiles versus equipment capacities. The Government will furnish fuel, utilities, other consumables, and provide personnel to operate the plant during testing. All test and/or measurement equipment shall be properly calibrated prior to its use.

7.1.2 Chillers. The efficiency of the existing chiller plant shall be analyzed and evaluated to determine if system efficiency can be improved or energy saving improvements implemented. The efficiency of the existing chillers shall be calculated using standard methods. Meters shall be used to obtain the necessary data to calculate efficiency. The AE is responsible for any metering necessary. If meters are existing, they may be used if their validated accuracy is within the limits specified below. If no meters are present, the AE is responsible for installing temporary meters. Permanent taps or connectors shall be installed so as to cause minimal disruptions to the system. Ultrasonic metering may be used. All meters used must have an accuracy of  $\pm 2$  percent and a statement to that effect, signed by an independent testing laboratory must be included in the report. Efficiency tests shall be made at normal operating parameters.

## 7.2 Survey Existing Plants

7.2.1 The condition of the existing plant shall be studied, documented, and evaluated. possibilities of repairing or replacing equipment or revising systems which will result in improved efficiency or reduced cost of operation shall be investigated.

7.2.2 The existing control system will be investigated, evaluated and documented to determine if equipment can be improved through upgrading, adjustment, repair or replacement, and if an alternate control system would increase efficiency. If an alternate system is recommended, interim improvements to existing controls shall also be recommended, if applicable. Engineering and economic analysis shall be developed. New controls proposed shall be Energy Monitoring and Control Systems (EMCS) compatible. Corps of Engineers Guide Specification (CEGS) 13946, Building Preparation for EMCS, shall be used as a standard for an interface to the existing plant. If an EMCS exists, interaction between this system and proposed modifications shall be clearly defined. The AE shall notify the DEH at least ten days prior to any pending outages of equipment and obtain concurrence prior to proceeding with any work.

7.2.3 The present boiler and chiller operation and maintenance practices shall be reviewed, documented, and evaluated with the intent to increase efficiency. The alternatives and recommendations shall be developed, evaluated, and documented in the report. Recommendations shall be in sufficient detail so that they can be quickly implemented. Detailed engineering and economic analysis of these actions are not required, however, a description and evaluation of these recommendations will be included in the report.

7.3 Identify ECOs. All methods of energy conservation which are reasonable and practical shall be considered, including operational methods and procedures and maintenance practices as well as physical facilities. A list of energy conservation opportunities is included as Annex A to this scope. This list is not intended to be restrictive but only to assure that at least these opportunities are considered, discussed and documented in the report. Each of the items shall considered and discussed in the report. Those items on the list which are not practical, have been previously accomplished, are inappropriate or can be eliminated from detailed analysis based on preliminary analysis shall be listed in the report along with the reason for elimination from further analysis. All potential ECOs which are not eliminated by preliminary considerations shall be thoroughly documented and evaluated as to the technical and economic feasibility. The AE shall provide all data and calculations needed to support the recommended ECO. All assumptions shall be clearly stated. Calculations shall be prepared showing how all numbers in the ECO were figured. Calculations shall be an or-

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derly step-by-step progression from the first assumption to the final number. Descriptions of the products, manufacturers catalog cuts, pertinent drawings and sketches shall also be included. A Life Cycle Cost Analysis Summary Sheet shall be prepared for each ECO and included as part of the supporting data.

7.4 (Deleted)

7.5 (Deleted)

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**7.6 Submittals, Presentations and Reviews.** The work accomplished shall be fully documented by a comprehensive report. The report shall have a table of contents and be indexed. Tabs and dividers shall clearly and distinctly divide sections, subsections, and appendices. All pages shall be numbered. The AE shall give a formal presentation of all but the final submittal to installation, command, and other Government personnel. The AE shall prepare slides or view graphs showing the results of the study to date for his presentation. During the presentation, the personnel in attendance shall be given ample opportunity to ask questions and discuss any changes deemed necessary to the study. A review conference will be conducted the same day, following the presentation. Each comment presented at the review conference will be discussed and resolved or action items assigned. The AE shall provide the comments from all reviewers and written

notification of the action taken on each comment to all reviewing agencies within three weeks after the review meeting. It is anticipated that each presentation and review conference will require approximately one working day. The presentation and review conferences will be at the installation on the date(s) agreeable to the Director of Engineering and Housing, the AE and the Government's representative. The Contracting Officer may require a resubmittal of any document(s), if such document(s) are not approved because they are determined by the Contracting Officer to be inadequate for the intended purpose.

**7.6.1 Interim Submittal.** An interim report shall be submitted for review after completion of the field survey and an analysis has been performed on all of the ECOs. The report shall indicate the work which has been accomplished to date, illustrate the methods and justifications of the approaches taken and contain a plan of the work remaining to complete the study. Calculations showing energy and dollar savings and SIRs of all the ECOs shall be included. The simple payback period of all ECOs shall be calculated and shown in the report. The AE shall submit the Scope of Work and any modifications to the Scope of Work as an appendix to the report. A narrative summary describing the work and results to date shall be a part of this submittal. During the review period, the Government's representative shall coordinate with the Director of Engineering and Housing and provide the AE with direction for packaging or combining ECOs for programming purposes and also indicate the fiscal year for which the programming or implementation documentation shall be prepared.

The survey forms completed during this audit shall be submitted with this report. The survey forms only may be submitted in final form with this submittal. They should be clearly marked at the time of submission that they are to be retained. They shall be bound in a standard three-ring binder which will allow repeated disassembly and reassembly of the material contained within.

**7.6.2 Prefinal Submittal.** The AE shall prepare and submit the prefinal report when all work under this contract is complete. The AE shall submit the Scope of Work for the installation studied and any modifications to the Scope of Work as an appendix to the submittal. The report shall contain a narrative summary of conclusions and recommendations, together with all raw and supporting data, methods used, and sources of information. The report shall integrate all aspects of the study. The report shall include an order of priority by SIR in which the recommended ECOs should be accomplished. The synergistic effects of all of the ECOs on one another shall have been determined and the results of the original calculations adjusted accordingly.

The prefinal report, separately bound Executive Summary and all appendices shall be bound in standard three-ring binders which will allow repeated disassembly and reassembly. The prefinal submittal shall be arranged to include (a) a separately bound Executive Summary to give a brief overview of what was accomplished and the results of this study using graphs, tables and charts as much as possible (See Annex D for minimum requirements), (b) the narrative report containing a copy of the Executive Summary at the beginning of the volume and describing in detail what was accomplished and the results of this study, (c) appendices to include the detailed calculations and all backup material.

A list of all projects and ECOs developed during this study shall be included in the Executive Summary and shall include the following data from the Life Cycle Cost Analysis Summary Sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date.

7.6.3 Final Submittal. Any revisions or corrections resulting from comments made during the review of the prefinal report or during the presentation and review conference shall be incorporated into the final report. These revisions or corrections may be in the form of replacement pages, which may be inserted in the prefinal report, or complete new volumes. Pen and ink changes or errata sheets will not be acceptable. If replacement pages are to be issued, it shall be clearly stated with the prefinal submittal that the submitted documents will be changed only to comply with the comments made during the prefinal conference and that the volumes issued at the time of the prefinal submittal should be retained. Failure to do so will require resubmission of complete volumes. If new volumes are submitted, they shall be in standard three-ring binders and shall contain all the information presented in the prefinal report with any necessary changes made. Detailed instructions of what to do with the replacement pages should be securely attached to the replacement pages.

8. OPERATION AND MAINTENANCE. The contractor will identify operational items noted during the study, which will effect energy conservation, and will explain the savings possible.

## ANNEX A

### GENERAL ENERGY CONSERVATION OPPORTUNITIES AND OTHER CONSIDERATIONS

#### General Energy Conservation Opportunities:

- o Controls to assure proper combustion air-fuel ratio.
- o Installation of new burner equipment.
- o Economizers/air preheaters.
- o Loading characteristics and scheduling versus equipment capacity (equipment optimization).
- o Control systems to operate chillers at their most energy efficient operating condition.
- o Variable or two-speed cooling tower fan.
- o Storage of chilled water.
- o High efficiency motors.
- o Instruments and controls to facilitate efficient operations.
- o Use smaller boilers where load has been reduced.
- o Replace inefficient boilers with more efficient boilers.
- o Replace inefficient chillers with more efficient chillers.

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- o Generate electricity on-site with natural gas turbine engines and reclaim heat from those engines to produce steam for steam turbine chillers or domestic hot water/steam.
- o Use natural gas engine driven chillers and reclaim heat from engines and condensers to produce domestic hot water.

Other Considerations (General Overview Only):

- o Provide the general impact on efficiency and capacity of changing the refrigerant to an environmentally safe refrigerant.
- o Generally, determine the extent of equipment modifications ("O" rings, gaskets, motor stators, controls, etc.) required for a new refrigerant.
- o Generally, determine special life safety features required when new refrigerants are used (sensors, alarms, ventilation, etc.).

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## ANNEX B

### DETAILED SCOPE OF WORK

1. General. This Detailed Scope of Work supplements the General Scope of Work and provides information and requirements specific to the Energy Survey of Army Boiler and Chiller Plants at Fort Sill. Any conflicts in requirements between the General and Detailed Scopes of Work will be resolved by the Corps of Engineers Project Manager.

2. Boiler/Chiller Plants to be Surveyed. Attachment 1 (Boiler/Chiller Plant List) to this Annex B lists the boiler/chiller plants (in priority order) to be surveyed under this contract. The Architect-Engineer (AE) will verify the pertinent data in Attachment 1 and develop a testing plan for each boiler/chiller. Those plans will outline the details of any modifications/attachments to plant equipment required in the tests and the plans will be provided to Fort Sill DEH for review and approval. The AE will comply with Occupational Safety and Health Administration (OSHA) Asbestos Standards 1910.1001 and 1926.58 and 40 CFR 61(m) in conducting any work involving asbestos. The AE will also address the Special Considerations outlined in Attachment 1 and present the findings in the report.

3. Previous Boiler/Chiller Plant Studies. As outlined in the General Scope of Work, the AE shall update boiler/chiller projects recommended in previous studies if they have not been implemented or programmed. The statuses of those previously recommended projects are as follows:

a. Central Energy Plant Nos. 445, 462, 730, 913, 1603, and 1653 to be replaced by single 800 Area central energy plant -- neither implemented nor programmed.

b. Chilled Water Plant No. 2471 (serving barracks Nos. 2470 and 2471) to be replaced with extension of chilled water piping from Plant No. 3442 -- designed, but not funded.

c. Central Energy Plant Nos. 5900 and 6003 to be expanded to serve future facilities -- Plant No. 5900 expansion has been completed; however, further expansion using waste oil/sludge fired boilers has been considered -- Plant No. 6003 expansion has neither been implemented nor programmed.

4. Government Furnished Information. The following information will be furnished as required and upon request of the AE:

a. Previously completed studies performed under the Energy Engineering Analysis Program (EEAP) and other programs. The AE may review study availability at Fort Sill DEH Energy Office.

- b. Fort Sill Energy Resources Management Plan.
- c. ETL 1110-3-282, Energy Conservation.
- d. ETL 1110-3-301, Entrance Doors to Heater/Boiler Rooms.
- e. ETL 1110-3-318, Procedures for Programming Energy Monitoring and Control Systems (EMCS) Funded Through the MCA Program.
- f. ETL 1110-3-332, Economic Studies.
- g. ETL 1110-3-354, Direct Digital Control of Heating, Ventilation and Air Conditioning (HVAC) Systems.
- h. Office, Chief of Engineers Architectural and Engineering Instructions, July 1989.
- i. Energy Conservation Investment Program (ECIP) Guidance, dated 25 April 1988 and revision dated 15 June 1989.
- j. Information on Existing EMCS Studies, Designs, Construction Contracts, or Operating Systems.
- k. TM 5-785, Engineering Weather Data.
- l. TM 5-800-2, General Criteria Preparation of Cost Estimates.
- m. TM 5-800-3, Project Development Brochure.
- n. TM 5-815-2, Energy Monitoring and Control Systems (EMCS).
- o. AR 415-15, Military Construction Army (MCA) Program Development.
- p. AR 415-17, Cost Estimating for Military Programming.
- q. AR 415-20, Construction, Project Development and Design Approval.
- r. AR 415-28, Department of the Army Facility Classes and Construction Categories.
- s. AR 415-35, Construction, Minor Construction.
- t. AR 420-10, General Provisions, Organization, Functions, and Personnel.
- u. AR 11-27, Army Energy Program.
- v. AR 5-4, Change No. 1, Depart of the Army Productivity Improvement Program.
- w. HNDSPP-84-076-ED-ME, Preliminary Survey and Feasibility Study for Energy Monitoring and Control Systems.
- x. NCEL CR 82.030, Standardized EMCS Energy Savings Calculations.
- y. HNDSPP88-207-ED-ME, HNDSPP88-208-ED-ME, HNDSPP88-209-ED-ME, and HNDSPP88-210-ED-ME, EMCS Cost Estimating Guides.
- z. Latest applicable Engineering Improvement Recommendation System (EIRS) Bulletin.
- aa. Example of a correctly completed implementation document for a project.
- bb. A computer program titled Life Cycle Costing in Design (LCCID) is available from the BLAST Support Office in Urbana, Illinois for a nominal fee to AE. This computer program can be used for performing the economic calculations for ECIP and non-ECIP ECOs. The AE is encouraged to obtain and use this computer program. The BLAST Support Office can be contacted at 144 Mechanical Engineering Building, 1206 West Green Street, Urbana, Illinois 61801. The telephone number is (217) 333-3977.

5. Submittals. The AE will make Interim, Prefinal, and Final submittals of the work under this contract as outlined in the General Scope of Work. Attachment 2 (Submittal List) to this Annex B lists the receiving offices, addresses, and number of copies for each submittal. The AE will make submittals directly to the offices listed with a copy of the transmittal letter to the Tulsa District Project Manager.

6. Delivery Schedule. The schedule for completing work under this contract is somewhat dependent on when the peak cooling and peak heating periods occur at Fort Sill. The following target milestones are based on boiler tests being completed by 1 March 1991. Chiller tests will be conducted during the summer of 1990.

<u>Item</u>	<u>Date</u>
Award AE Contract	24 Aug 1990
Interim Submittal	1 May 1991
Interim Submittal Comments	31 May 1991
Prefinal Submittal	1 Aug 1991
Prefinal Submittal Comments	30 Aug 1991
Final Submittal	30 Sep 1991

7. Project Managers/Coordinators. The following persons will serve as points of contact and liaison for all work required under this contract:

AE: (As designated at time of contract award)

Tulsa District: Merle London  
US Army Engineer District, Tulsa  
ATTN: CESWT-EC-PF  
PO Box 61  
Tulsa, OK 74121-0061  
Tele. No. (918) 581-7991  
FAX (918) 581-7365

Fort Sill: Gary Basham  
US Army Field Artillery Center and Fort Sill  
ATTN: ATZR-EE  
Fort Sill, OK 73503-7200  
Tele. No. (405) 351-3517  
FAX (405) 351-6923

# ANNEX B - ATTACHMENT 1

## BOILER/CHILLER PLANT LIST

Item	Plant	No. Chillers*	Tons	No. Boilers*	MBTU
Base	: 5900	: 5 (F)	: 2000	: 6 (F)	: 65.20
Base	: 6003	: 3 (F)	: 1300	: 3 (F)	: 16.20
Base	: 730	: 3 (F)	: 1440	: 4 (F)	: 15.99
	:	:	:	:	:
Opt 1	: 2812	: 1 (F)	: 372	: 3 (F)	: 6.03
Opt 2	: 4701	: 2 (F)	: 610+	: 3 (F)	: -
Opt 3	: 5676	: 1 (P)	: 375	: 2 (P)	: 2.98
Opt 4	: 5678	: 1 (P)	: 190	: 2 (P)	: 3.95
Opt 5	: 3442	: 2 (P)	: 1200	: No Boilers	: -
Opt 6	: 914	: 1 (P)	: 400	: 4 (P)	: -
	:	:	:	:	:
Opt 7	: 1603	: 1 (P)	: 345	: 4 (M)	: -
	:	:	:	:	:
Opt 8	: 3040	: 1 (P)	: 350	: 2 (P)	: -
	:	:	:	:	:
Opt 9	: 500	: 1 (P)	: 110	: 1 (P)	: -
	:	:	:	:	:
Opt 10	: 1490	: 1 (P)	: 150	: 2 (P)	: -
	:	:	:	:	:

NOTE: Above data were extracted from existing records and contain errors/omissions. A-E and Government will jointly verify the data prior to contract negotiations.

- \* (F) = Full Test, as detailed in Pre-Negotiation minutes.
- (P) = Partial Test, as detailed in Pre-Negotiation minutes.
- (M) = Minimum Test, as detailed in Pre-Negotiation minutes.

Annex B - Attachment 1

ANNEX B - ATTACHMENT 1 (Cont.)

Special Considerations.

Plant No. 730: Determine if capacity of plant is sufficient to serve additional buildings.

Plants Nos. 5676 and 5678: Determine the feasibility of interconnecting these two plants.

Plant No. 3442: Explore opportunity for central heating plant. This proposition was investigated in previous studies.

Plant No. 914: Determine feasibility of using one boiler to serve four buildings (similar to single chiller in plant).

Plant No. 4701: Plant was designed for hospital use, but is to be now used for other purposes. Consider downgrading system to low pressure steam and use excess capacity elsewhere.

Annex B - Attachment 1

ANNEX B - ATTACHMENT 2

SUBMITTAL LIST  
FORT SILL BOILER/CHILLER SURVEY

Organization

Submittals

USAED, Tulsa  
ATTN: CESWT-EC-PF/London  
PO Box 61  
Tulsa, OK 74121-0061

5 cys - all submittals

USAED, Southwestern  
ATTN: CESWD-ED-MM/Hasley  
1114 Commerce Street  
Dallas, TX 75242-0216

1 cys - all submittals

Commander, USAFACAFS  
ATTN: ATZR-EE/Basham  
Bldg 1945  
Fort Sill, OK 73503-7200

3 cys - all submittals

Commander, TRADOC  
ATTN: ATEN-FE/Capra  
Fort Monroe, VA 23651-5000

1 cys - all submittals

Commander, HQUSACE  
ATTN: CEMP-ET/Beranek  
20 Massachusetts Ave NW  
Washington, DC 20314-1000

Executive Summaries only

HQDA  
ATTN: DALO-TSE/Maj Davies  
Pentagon  
Washington, DC 20310-0561

Executive Summaries only

USAED, Mobile  
ATTN: CESAM-EN-CC/Battaglia  
PO Box 2288  
Mobile, AL 36628-0001

Final Submittal only

ANNEX C  
REQUIRED DD FORM 1391 DATA

(Deleted)

C-1

REPRODUCED AT GOVERNMENT EXPENSE

## ANNEX D

### EXECUTIVE SUMMARY GUIDELINE

1. Introduction.
2. Boiler Data. (Number, sizes, efficiency, etc.)
3. Present Energy Consumption.
  - o Total Annual Energy Used.
  - o Source Energy Consumption.
    - Electricity - KWH, Dollars, BTU
    - Fuel Oil - GALS, Dollars, BTU
    - Natural Gas - THERMS, Dollars, BTU
    - Propane - GALS, Dollars, BTU
    - Other - QTY, Dollars, BTU
  - o Energy Consumption by Systems.
4. Historical Energy Consumption.
5. Energy Conservation Analysis.
  - o ECOs Investigated.
  - o ECOs Recommended.
  - o ECOs Rejected. (Provide economics or reasons)
  - o ECIP Projects Developed. (Provide list)\*
  - o Non-ECIP Projects Developed. (Provide list)\*
  - o Operational or Policy Change Recommendations.

\* Include the following data from the Life Cycle Cost Analysis Summary Sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date. For all programmed projects also include the year in which it is programmed and the programmed year cost.
6. Energy and Cost Savings.
  - o Total Potential Energy and Cost Savings.
  - o Percentage of Energy Conserved.

- o Energy Use and Cost Before and After the Energy Conservation Opportunities are Implemented.

**7. Energy Plan.**

- o Project Breakouts with Total Cost and SIR.
- o Schedule of Energy Conservation Project Implementation.



E M C ENGINEERS, INC.  
2750 S. Wadsworth Blvd., Suite C-200  
Denver, Colorado 80227  
303/988-2951

CONFIRMATION NOTICE

CONFIRMATION NOTICE NO. 1

DATE: 5 July 1990

PROJECT: Central Energy Plant Study  
Ft. Sill, Oklahoma

NOTES

PREPARED BY: Carl E. Lundstrom  
E M C Engineers, Inc.

DATE OF  
CONFERENCE: 4 June 1990

PLACE OF  
CONFERENCE: DEH Office, Ft. Sill, Oklahoma

PURPOSE OF  
CONFERENCE: Conference to discuss questions related to the Central Plant Study.

ATTENDEES: Carl E. Lundstrom, E M C Engineers, Inc.  
Merle London, Tulsa District, COE  
Jerry Schmidt, Ft. Sill DEH

CONFERENCE NOTES:

The following is a summary of the items discussed, the comments made, and the decisions made during the Conference.

1. The "Scope Reduction" pages were discussed. Mr. Schmidt agreed the scope reductions seemed reasonable in order to get the project within the project budget.
2. Mr. Lundstrom and Mr. London went through the original scope of services and made corrections, deletions, and changes related to the "Scope Reduction" pages.
3. Mr. London said he would revise the scope and mail a new request for proposal.
4. Mr. Lundstrom said he would start preparing a revised proposal.

  
Carl E. Lundstrom

cc: Merle London  
Jerry Schmidt

Gary Basham  
Carl Lundstrom

## SCOPE REDUCTION

The following proposed scope changes to the "Energy Survey of Army Boiler and Chiller Plant For Ft. Sill, Oklahoma" are listed for Tulsa District's information.

### TESTING:

#### CHILLER:

- o Eliminate cooling tower testing.
- o Reduce chiller testing metering to the minimum required to calculate efficiency performance at full load: chiller kW input, chilled water flow, chilled water supply and return temperature, condenser water flow, and condenser water supply and return temperature. Flow readings would be taken with ultrasonic flow meters.
- o The chiller testing would only involve measurements at one chilled water and one condenser water setpoint; plus taking the single point pressure, temperature, and kW measurements as originally indicated.
- o Interview operators and report condition.
- o Run chiller through operating range to observe conditions.
- o Observe cooling tower temperature control system.

#### BOILERS:

- o The boiler testing would involve
  - Taking orsat test (flue gas analysis measurements) while boilers is operating at low fire and high fire.
  - Record gas flow to boiler through existing meters if available.
  - Record temperature, pressure, and flow data through existing meters if available.
  - Correlate part load and full load capacity with manufacturers data and orsat test.
  - Interview operators and report condition of equipment.
  - Obtain operator log data that is available.

### MEETINGS:

- o Eliminate the O&M training, and related materials.

### ANALYSIS:

- o Eliminate 6 of 11 boiler energy conservation opportunities (ECO's) identified. ECO's left include:
  - Replacement of boilers.
  - Control systems.
  - Installation of new burners.

- Economizer/Air Preheater.
- High efficiency motors.
- o Eliminate 5 of 10 chiller ECO's identified. ECO's left include:
  - Replacement of chillers.
  - Control systems.
  - Variable and two speed motors
  - Storage of chilled water or other thermal storage systems.
  - High efficiency motors.
- o Eliminate all cooling tower ECO's.
- o Eliminate cooling tower computer modeling
- o Eliminate analysis of impact on existing chillers due to changing the refrigerant to an environmentally safe refrigerant and related requirements.

REPORT DEVELOPMENT:

- o Eliminate programming document preparation.
- o Eliminate implementation document preparation.
- o Eliminate O&M training manual development.

[c:\jobs\p10f.12\scope.wp]

CONFIRMATION NOTICE

CONFIRMATION NOTICE NO. 2

DATE: 26 September 1990

PROJECT: Energy Survey of Army Boiler and Chiller Plants  
Ft. Sill, Oklahoma  
Contract No. DACA 56-90-C-0087

NOTICE

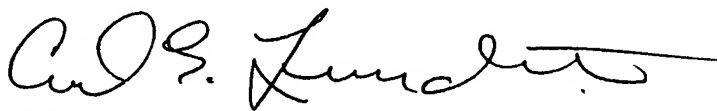
PREPARED BY: Carl E. Lundstrom  
E M C Engineers, Inc.

This is to confirm a conversation on 11 September 1990 between Merle London, Project Manager, Tulsa District Corps of Engineers, and Carl E. Lundstrom regarding documents related to the contract.

Mr. Lundstrom discussed with Mr. London that four sets of information were prepared and circulated during the negotiations of the referenced contract, which more clearly defined and refined the scope of services. Mr. Lundstrom wanted to reconfirm that these four documents are made part of the contract by this confirmation notice. The three documents are:

- Confirmation Notice No. 1, dated 5 July 1990, regarding "Scope Reductions."
- Conference Notes, dated 1 May 1990.
- Basis of Fee, submitted with fee proposal.
- Test Procedures, dated 14 June 1990.

Mr. London agreed the documents are part of the contract.



Carl E. Lundstrom, P.E.

## CONFIRMATION NOTICE

Confirmation No. 3

EMC #3002.000

DATE: February 27, 1991

PROJECT: Energy Survey of Army Boiler and Chiller Plants  
CONTRACT NO: DACA 56-90-C-0087

NOTICE  
PREPARED BY: Pawn Chulavatr  
E M C Engineers, Inc.

DATE OF  
CONFERENCE: February 13, 1991

PLACE OF  
CONFERENCE: Ft. Sill, Oklahoma

SUBJECT: Exit Interview Meeting Notes

ATTENDEES:	Merle London	Tulsa District COE	(918) 581-7991
	Serge Saltiel	DEH-Ft. Sill	(405) 351-5708
	Jerry Schmidt	DEH - Engineer Design	(405) 351-4250
	Carl Swenson	EMC Engineers, Inc.	(303) 988-2951
	Pawn Chulavatr	EMC Engineers, Inc.	(404) 952-3697

The following is a summary of items discussed, the comments made, and the decision made during the meeting.

EMC reported the preliminary results of the boiler survey. EMC stated that the combustion efficiency test of boilers went well and only one boiler is out of commission (building 4701). There were a few other minor problems encountered. Overall the test results were satisfactory. The preliminary result of the boiler testing is averaging around 77% efficiency.

Mr. Swenson suggests Ft. Sill train specialized groups of personnel in testing/calibrating boilers in all central plants. He expresses the lack of permanent instrumentation such as stack temperature gauge, pump pressure gauge, and opening for flue gas testing on boilers in the central plant. Mr. London asked that these suggestions be put in the report. EMC agreed to incorporate findings and suggestions into the report.

EMC described present operating procedures of boilers in the central plants according to the boiler operators. EMC reported that the only boiler log data was obtained from Central Plant 5900. The other central plants do not have log data.

CONFIRMATION NOTICE

February 27, 1991

Page 2

Mr. Schmidt expressed interest in creating a central heating plant as an addition to chiller central plant in buildings 3442 and 730, utilizing existing underground piping.

Special Notes:

1. For the purpose of determining the base load on central plants, EMC is using the assumption that the proposed buildings listed for the EMCS in the DD1391 Validation Study will be connected to the EMCS. These buildings will incorporate day/night setback and other energy savings associated with EMCS.
2. EMC found the heating and cooling log data was either known to be false (stated by the operators) or upon checking, has been determined to be invalid. Because of the lack of this information, EMC will estimate the loads on the central plants based on BTU per square feet data obtained from previous studies. EMC will also use sound engineering judgment in applying the historical load data to the building and plants involved in this study.

If this method is unsatisfactory, EMC must be notified as soon as possible.



Pawn Chulavatr

## CONFERENCE NOTES

DATE: 26 September 1990

PROJECT: Energy Survey of Army Boiler and Chiller Plants  
Ft. Sill, Oklahoma  
Contract No. DACA 56-90-C-0087

### NOTICE

PREPARED BY: Carl E. Lundstrom  
E M C Engineers, Inc.

DATE OF  
CONFERENCE: 11 September 1990

PLACE OF CONFERENCE: DEH Conference Room, Ft. Sill, Oklahoma

PURPOSE OF CONFERENCE: Entry Interview

ATTENDEES: Merle London, Tulsa District, Corps of Engineers, (918) 581-7991  
Carl Lundstrom, E M C Engineers, Inc., (404) 952-3697  
Carl Swenson, E M C Engineers, Inc., (303) 988-2951  
Kenneth Rodgers, DEH HVAC, Ft. Sill  
Jerry Schmidt, DEH, Ft. Sill, (405) 351-4250  
Doug Cook, DEH Energy, Ft. Sill, (405) 351-3225

1. Mr. Lundstrom provided an overview of the scope of services, including testing, energy conservation opportunities (ECOs), and documentation of the plants to be evaluated.
2. Mr. Lundstrom described the test procedures to be conducted on the chillers and boilers. He described that the test on the chillers would be conducted immediately and the boiler testing would be conducted during winter months (December-February).
3. Mr. Lundstrom presented his list of personnel conducting the survey, his proposed schedule, and proposed working hours. Mr. Rodgers saw no problem providing RVAC shop personnel for the proposed survey schedule.
4. Mr. London discussed that EMC should be very careful when removing insulation, so as to not have asbestos problems. Mr. Lundstrom agreed with the situation. Mr. Schmidt agreed to contact Mr. Goode at Ft. Sill environmental regarding the testing of insulation for asbestos.
5. Mr. Lundstrom asked if it would be a problem to shut off chillers, or take load off of chillers temporarily so as to increase the load for testing purposes. Mr. Rodgers did not see a problem with this.

6. Mr. Swenson asked about the general condition of chillers and annual maintenance procedures. Mr. Rodgers explained the chillers are generally in good condition and the condensers are all cleaned before each cooling season.
7. Mr. Schmidt emphasized he is interested in adding more buildings to central plants, especially in those facilities where there is extra cooling capacity.
8. Mr. Cook discussed the Energy Department is interested in developing energy conservation projects for future funding.
9. Mr. Lundstrom agreed to prepare conference notes, and the meeting was adjourned.



Carl E. Lundstrom, P.E.

Enclosure: Meeting Agenda

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL  
CONTRACT DACA56-90-C-0087**

**ENTRY INTERVIEW**

**AGENDA**

**1. GENERAL OVERVIEW OF PROJECT**

- Testing of boiler and chillers for efficiency of plant.
- Determine current operating procedures of plants.
- Identify energy conservation opportunities (ECO).
- Perform analysis to determine energy consumption of plants, and evaluate ECO's.
- Prepare comprehensive report documenting the findings of the survey and analysis.
- Central Plants,
  - 5900
  - 6003
  - 730
  - 2812
  - 5676
  - 5678
  - 3442
  - 914
  - 4701

**2. INTENDED PROCEDURES**

- Chiller Testing, September 1990
- Boiler Testing, January 1991  
(see attached test procedures)

**3. SCHEDULE - CHILLER TESTING**

Tuesday, 9/11, Building 2812  
Wednesday, 9/12, Building 6003  
Thursday, 9/13, Building 730  
Friday, 9/14, Building 730 & 914  
Saturday, 9/15, Building 5900  
Monday, 9/17, Building 5900  
Tuesday, 9/18, Building 3442  
Wednesday, 9/19, Building 5676  
Thursday, 9/20, Building 5678  
Friday, 9/21, Building 4701  
Saturday, 9/22, optional  
Monday, 9/24, optional

**4. PERSONNEL CONDUCTING SURVEY**

Carl E. Lundstrom  
Carl A. Swenson  
Jim Watters

**5. PROPOSED WORKING HOURS**

07:30 to 18:00 hours, dates as shown

**6. DEH SUPPORT**

One RVAC shop chiller personnel, to bring chillers on and off line for testing. Also EMC will interview RVAC personnel to determine how plants are currently operated.

**7. DISCUSSION**

Any chillers plants not operational that can not be tested?  
Other

**TEST PROCEDURES**  
**Energy Survey of Army Boiler and Chiller Plants**  
**Fl. Sill, Oklahoma**  
**Page 1 of 3**

Date: 14 June 1990  
EMC Project No.: P10E.012

INTER-DEPARTMENTAL  
PROJECT  
PLS-10E-012 (01/90) 0000000000

**Boiler Testing:**

The boiler test procedure is designed to determine the efficiency of the boiler plants. The procedure is based on the American Society of Mechanical Engineers (ASME) Power Test Code 4.1 and will utilize instrumentation provided by EMC Engineers, Inc. It is noted that this procedure does not strictly adhere to ASME PTC 4.1; it is designed to provide the necessary data while controlling costs. The data obtained during the testing will be used to analyze boiler-related Energy Conservation Opportunities (ECO's). A single reading of the following will be measured:

- Flue gas temperature
- Ambient (combustion) air temperature
- Flue gas CO<sub>2</sub> content
- Flue gas O<sub>2</sub> content
- Outside air temperature
- Outside air relative humidity
- Fuel flow (using existing meters)
- KW input to primary hot water circulation pumps
- Differential pressure on representative primary hot water circulation pumps

Boiler readings will be taken while the boiler is under steady state firing conditions to the extent practical. The test procedure is as follows:

- 1) Install Flue gas thermometer and sampling tube in the stack through existing penetrations if possible. If not, a new penetration will be made using a handheld drill.
- 2) For non modulating burners, set burner control to hi-fire setting (if applicable). Adjust controls of other boilers so that the boiler being tested fires continuously.
- 3) For modulating burners, set burner control to manual, constant setting. Adjust controls of other boilers so that the conditions of the boiler being tested remain relatively steady.
- 4) Observe the following operating conditions relative to manufacturer's recommendations:
  - steam/hot water pressure/temperature setpoints
  - boiler water level

**TEST PROCEDURES**  
**Energy Survey of Army Boiler and Chiller Plants**  
**Ft. Sill, Oklahoma**  
**Page 2 of 3**

- flame configuration
  - combustion control
  - make-up water control
  - leaking safety and other valves
  - signs of leaking boiler tubes
  - general condition of boiler insulation
- 5) Record data.
- 6) Remove instrumentation, return control settings to original positions.

**Chiller Testing:**

This chiller test procedure is made with the intent of determining the efficiency of the chiller plants. The procedure is based on the Air-Conditioning and Refrigeration Institute (ARI) Standard for Centrifugal or Rotary Screw Water-Chilling Packages (ARI 550-88). The procedure will utilize instrumentation provided by EMC Engineers, Inc. It is noted that this procedure does not strictly adhere to ARI 550-88; it is designed to provide the necessary data while controlling costs. The data obtained during the testing will be used to analyze chiller-related ECO's. A single set of readings of the following points will be metered:

- Condenser water inlet temperature
- Condenser water outlet temperature
- Chilled water return temperature
- Chilled water supply temperature
- Chilled water flow
- Chiller Compressor KW input
- Outside air temperature
- Outside air relative humidity
- KW input to chilled and condenser water pumps
- Differential pressure on representative chilled and condenser water pumps
- Condenser inlet/outlet pressure differential
- Evaporator inlet/outlet pressure differential

Readings will be taken at normal chilled water and condenser water supply temperature setpoints. "Normal setpoints" is meant to mean the setpoints used under normal operating conditions by the Ft. Sill maintenance staff. The test procedure is as follows:

- 1) Install all chiller test equipment.
- 2) Adjust setpoints to normal positions. Allow time for chiller to reach steady-state

**TEST PROCEDURES**  
**Energy Survey of Army Boiler and Chiller Plants**  
**Ft. Sill, Oklahoma**  
**Page 3 of 3**

conditions. Steady-state is considered to be established after three sets of data have been taken, at five minute intervals, where the readings remain within the tolerances set forth in ARI 550-88, Para. A7.2.

Practical steps will be taken to obtain steady-state conditions. If these conditions are not reached within 1 hour, the EMC test engineer will use his discretion as to how to proceed with the testing.

- 3) Have DEH personnel remove all non-condensables from the system.
- 4) During the testing, observe the following operating conditions relative to manufacturer's recommendations:
  - refrigerant charge
  - temperatures and pressures
  - speed control
- 5) After the chiller conditions have stabilized, take a single set of readings.
- 6) Remove instrumentation.

At the time of the tests, DEH personnel will be interviewed as to the time of last cleaning and the general cleanliness of all heat exchangers. This information will be used to estimate fouling factors.

**BASIS OF FEE**  
**Energy Survey of Army Boiler and Chiller Plants**  
**Ft. Sill, Oklahoma**  
**Page 1 of 3**

The proposal for the above project is based on the following items:

1. EMC will use existing natural gas meters in the boiler plants at Ft. Sill. EMC will not install any additional gas meters.
2. One complete set of metering equipment will be used. This equipment will all be direct readout type equipment; an electronic data acquisition system with sensors, PC, etc. will not be used. Equipment purchased for the project and to be given to the Government at the end of the project are as follows:
  - (2) Stack Thermometers
  - (1) Ultrasonic Flow Meter
  - (6) Thermometers
  - (1) Handheld Flue Gas Analyzer
  - (6) Pressure Gages
3. Asbestos Containing Materials (ACM) removal will amount to no more than (8) horizontal type 44" wide by 60" long glove bags.
4. Any material that is suspected by EMC to be ACM will be treated as ACM unless that material is sampled, tested, and positively identified by the Government as not being ACM. Sampling and testing must be performed according to all applicable EPA, OSHA, and other Federal, State, Regional, and Local regulations.
5. All ACM removal will be classified by EPA regulations as "O & M removal".
6. All ACM removed will be disposed of at the approved ACM disposal site at Ft. Sill.
7. All necessary pipe penetrations are existing. No additional pipe penetrations will be required for the testing.
8. Equipment outages of short duration will be required to connect meters. It is not expected that these outages will significantly effect plant operation. A general schedule of outages will be provided at the survey entrance interview. Given the nature of the survey work, providing a detailed schedule of outages is not possible.
9. In Appendix A, General Scope of Work, Para. 2.1, the phrase "updated and included" is taken to mean as follows: No technical analysis will be done under this contract. An

### CONFERENCE NOTES

DATE: 1 May 1990

PROJECT: Ft. Sill  
Energy Survey of Army Boiler and Chiller Plants

#### NOTES

PREPARED BY: Carl E. Lundstrom, P.E.  
E M C Engineers, Inc.

DATE OF  
CONFERENCE: 17 April 1990

PLACE OF  
CONFERENCE: DEH Office, Ft. Sill, Oklahoma

PURPOSE OF  
CONFERENCE: Pre-negotiation conference to discuss questions related to the Ft. Sill energy survey of Army boiler and chiller plants

ATTENDEES: F. Mike Denham, E M C Engineers, Inc., (303)988-2951  
Carl E. Lundstrom, E M C Engineers, Inc., (404)952-3697  
Merle London, Tulsa District, COE, (918)581-7991  
Gary W. Basham, Ft. Sill DEH, (405) 351-3517  
Jerry E. Schmidt, Ft. Sill DEH, (405) 351-4250  
Steve McManus, Ft. Sill Energy Conservation Office, (405) 351-3225  
Ron Barnett, Environmental Division, (405) 351-2715  
Don Goode, Environmental Division, (405) 351-2715

#### CONFERENCE NOTES:

The following is a summary of the items discussed, the comments made, and the decisions made during the Conference. The A/E statement of work and conference agenda were distributed to each person.

1. M. London opened the conference with general introductions and explanation of the scope of the project. EMC is to survey boilers and chillers at Ft. Sill, determine their operating efficiency, evaluate energy conservation opportunities, and prepare three submittals of the testing and analysis. In addition EMC is to provide a one-day training seminar.

2. Asbestos removal concerns were discussed with R. Barnett. EMC will be installing instrumentation on the boilers and chillers to test their efficiency. Piping and flue insulation will have to be removed. Unless the insulation has been sampled, tested and positively

identified as not having asbestos containing material (ACM), it will be treated as asbestos. Paragraph 2. in Annex B, in the statement of work, identifies the OSHA standard which must be followed by workers that will be in areas with ACM's. R. Barnett explained if ACM will be removed and disposed of, EMC must follow EPA regulation Title 40CFR 61 (m). It was felt the work would be classified as O&M removal. EMC should investigate inspection notification, ACM removal, and ACM disposal requirements. EMC will have to contract with a licensed ACM removal contractor for this work. The government has an approved ACM disposal site at Ft. Sill for the material.

The following questions relate to Appendix A, General Scope of Work for an Energy Survey of Army Boiler and Chiller Plants for Ft. Sill Oklahoma:

3. Paragraph 2.1: Only the previous studies identified in Annex 'B' paragraph 3.a.b.& c. and related projects in Annex 'B' attachment 1 (cont.) must be updated and included in this study.

4. Paragraph 2.3: The statement that the study shall include supporting systems such as fuel oil storage, pollution abatement, etc. is meant to only note those items related to the existing boiler and chiller plant, which seem not normal, in need of repair, etc. Detailed evaluation of these items is not required.

5. Paragraph 2.3: The study is not intended to include a detailed evaluation of the distribution systems related to the central plants. If EMC notes problems while on-site (such as steam leaks in piping pits) these items should be described briefly in the report.

6. Paragraph 2.5: The term "technically and economically feasible," is meant to be those items which have been done and proven to provide savings, i.e. nothing experimental. All ECO's should be coordinated with DEH on what's feasible for Ft. Sill.

7. Paragraph 2.8: ECAM evaluation does not apply to Ft. Sill. Delete this requirement from the statement of work.

8. Paragraph 3.4: EMC will not be required to attend any non-scheduled meetings. EMC will have a kickoff meeting at the beginning of the field survey, and an exit interview, plus the scheduled submittal review meetings.

9. Paragraph 3.7.1.c: There will be no major restrictions on the working hours for EMC. EMC shall coordinate it's working schedule with DEH.

10. Paragraph 7.1.1: The statement of work regarding "submit...testing laboratory to the Contracting Officer for approval, is meant to include submitting documentation showing testing equipment has been properly calibrated.

11. Paragraph 7.1.1: The efficiency testing requirements for boilers were divided into full testing, partial testing, and minimum testing requirements, based on the size and age of the plants (see Annex B - attachment 1).

Full efficiency testing is to include: Installation of instrumentation for input/output measurement required to meter energy in versus energy out. See attached diagrams for instrumentation of low temperature hot water boilers (LTHW), high temperature hot water boilers (HTHW), and steam boilers.

Partial efficiency testing is to include: Stack temperature and CO measurements to determine the boiler combustion efficiency, plus overall inspection of the general boiler condition and operation. See attached diagrams for instrumentation of low temperature hot water boilers (LTHW), high temperature hot water boilers (HTHW), and steam boilers.

Minimum testing is to include: Overall inspection of the general condition and operation. No instrumentation will be used for this testing.

It is assumed one set of instrumentation equipment will be used for the measurements. This set of instrumentation will be moved from boiler to boiler to make the required measurements. In those locations where an insertion flow meter will be used, a new pipe tap and full bore valve will be installed and left in place after the metering is complete.

EMC will be required to remove asbestos insulation on pipes and stacks as required to make measurements (see item 2.).

12. Paragraph 7.1.2: The efficiency testing requirements for chillers were divided into full testing, partial testing, and minimum testing requirements, based on the size and age of the plants (see Annex B - attachment 1).

Full efficiency testing is to include: Installation of instrumentation for input/output measurement required to meter energy in versus energy out. See attached diagrams for instrumentation of chillers.

Partial efficiency testing is to include: The same as full efficiency testing minus the flow metering installation. See attached diagrams for instrumentation of chillers.

Minimum testing is to include: Overall inspection of the general condition and operation. No instrumentation will be used for this testing.

It is assumed one set of instrumentation equipment will be used for the measurements. This set of instrumentation will be moved from

chiller to chiller to make the required measurements. In those locations where an insertion flow meter will be used, a new pipe tap and full bore valve will be installed and left in place after the metering is complete.

For the full and partial testing EMC will measure the efficiency of the plants at varying loads at the following setpoints:

- Chilled water supply setpoints: 44°, 46°, and 48°, at the normal condenser water setpoint temperature.
- Condenser water supply setpoints: 87, 85, and 82, at the normal chilled water supply setpoint temperature.

EMC will be required to remove asbestos insulation on pipes as required to make measurements (see item 2.).

13. Paragraph 7.2.3: This paragraph is not intended to write an O&M manual for boiler and chiller operation. Include O&M items which would be covered in the one-day training class related to this project.

14. Paragraph 7.5: It was decided \$25,000 or less was the limit for a low cost/no cost ECO.

15. Paragraph 7.6.1: The sample completed DA Form 5108-R should be submitted with the interim submittal. EMC should coordinate with DEH which project should be submitted prior to the interim submittal.

16. Paragraph 8.: EMC will be required to give the one-day training class on three consecutive days, to three different classes of maintenance personnel at Ft. Sill. EMC should estimate on having 15 persons per class.

General comments and questions:

17. Mr. Lundstrom asked about evaluating manpower operation requirements. Mr. Basham explained this was a touchy subject, but is an important area to review. EMC should coordinate all information very closely with DEH, prior to submittals.

18. Mr. Lundstrom explained that to perform detailed ECO calculations, detailed boiler log data would provide the best method of estimating hourly loads. Because there are little or no log data kept, EMC will have to estimate loads, from gross capacities, or what little monthly metering data that's available.

19. After the study is complete, EMC will leave the metering equipment for government to use. There is little or no measurement or metering instrumentation on the central plants. This equipment can be used in the future for metering and adjusting central plant equipment operations. Some of the metering equipment will be site specific for the metering installations.

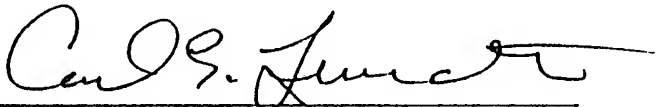
20. EMC will have to review the scheduling impact of: 1) submitting metering plan for approval, and 2) having contractors install metering taps and asbestos abatement.

21. Annex A, regarding impact of new refrigerants, EMC will address: 1) the general question of the affect refrigerant changes will have on Ft. Sill, and the central plants in question, 2) generally what efficiency, equipment changes, capacity, and life expectancy changes will occur, 3) manufacturers input to equipment changes required, 4) a general discussion on cost to convert chillers versus replacement of chillers, 5) life safety requirements for new refrigerants, and 6) general design guidelines and directives for future chiller plant designs. Specific chiller by chiller evaluation for technical modifications will not be provided in this study.

Ft. Sill DEH is to provide EMC with copies of the as-built mechanical plans for the chiller and boiler plants that will require instrumentation installations for measurement, for EMC to prepare a construction estimate for their fee proposal. Ft. Sill is to provide EMC a list of names of mechanical and asbestos abatement contractors who have worked at Ft. Sill.

Tulsa District needs to provide the following documents for EMC to prepare their fee proposal:

1. AR415-17, Tri-Service MCP Index, and EIRS bulletin.
2. Latest ECIP guidance.
3. AR5-4, change no. 1.
4. ETL 1110-3-332.
5. AR415-15, MCP Data, DD Form 1391
6. AR415-20.
7. TM5-800-3 for PDB.
8. Copy of a completed PDB.
9. DA Form 5108-R, copy of a blank form, instructions for completing the form, and a completed form as an example.
10. Copy of a completed DA Form 5108-R.
11. Example completed implementation document



Carl E. Lundstrom, P.E.  
Project Manager

[C:\JOBS\SILL\CONFNOTE.WP]

**BASIS OF FEE**  
**Energy Survey of Army Boiler and Chiller Plants**  
**Ft. Sill, Oklahoma**  
**Page 2 of 3**

economic analysis will be done using the previous technical analysis results and current economic data. Construction cost estimates from the previous studies will be adjusted for inflation. All necessary technical analysis results from the previous studies will be provided by the Government. Only previous studies that effect the boiler/chiller plants in this study and that are identified in Annex B, Attachment 1, Detailed Scope of Work will be included in this study.

10. The manufacturer's published technical data will be sufficient certification of accuracy for meters and other test equipment that are new (not previously used).
11. EMC will have the full-time assistance of a boiler/chiller operator from Ft. Sill to perform equipment changeover. This will require approximately 1-1/2 weeks during the chiller testing in July or August 1990 and approximately 1 week during the boiler testing in January 1991.
12. Annex A to the General Scope of Work "General Energy Conservation Opportunities and Other Considerations" is revised to eliminate redundant ECO's and to combine certain ECO's to allow for practical implementation and valid technical analysis. Annex A will read as follows:  
  
General Energy Conservation Opportunities:
  - 1) Replacement of Boilers
  - 2) Installation of New Burners and Control Systems (to assure proper combustion air-fuel ratio and most economical operation, including equipment optimization)
  - 3) Economizers/Air Preheaters
  - 4) High Efficiency Motors on Primary Hot Water Circulation Pumps and Chilled and Condenser Water Pumps.
  - 5) Variable or Two Speed Motors on Primary Hot Water Circulation Pumps and Chilled and Condenser Water Pumps.
  - 6) Replacement of Chillers
  - 7) Control Systems (to operate chillers at most economical conditions, including equipment optimization)
  - 8) Storage of Chilled Water
13. No additional ECO's will be analyzed in detail. No ECAM projects will be included. A general discussion of possible low cost / no cost ECO's observed during the surveys will be included in the report.
14. No heating or electrical load calculations are included. These loads will be provided by the Government, as required.

**BASIS OF FEE**  
**Energy Survey of Army Boiler and Chiller Plants**  
**Ft. Sill, Oklahoma**  
**Page 3 of 3**

15. EMC project team members will make four trips to Ft. Sill. They are as follows:
  - 1) Chiller testing (approximately 1-1/2 weeks)
  - 2) Boiler testing (approximately 1 week)
  - 3) Interim Report Submittal Presentation
  - 4) Prefinal Report Submittal Presentation
16. No more than two EMC personnel will take part in each site visit to Ft. Sill. This includes the surveys and the submittal presentations.
17. Boiler/Chiller plants 5900, 6003, and 730 are included.
18. Travel costs were established based on 14 day prior notice.

Any additional effort to that indicated above will be accomplished through a modification to the contract.

8.15.91

FORT SILL REVIEW COMMENTS			DATE	ACTION A CONCUR D DO NOT CONCUR E EXCEPTION X DELETE  (EXPLAIN D, E, & X)  ACTION BY COMPLY _____
DIRECTORATE OF ENGINEERING & HOUSING			DISCIPLINE  <input type="checkbox"/> CIVIL <input type="checkbox"/> ARCHITECTURAL <input type="checkbox"/> MECHANICAL <input type="checkbox"/> ELECTRICAL <input type="checkbox"/> FIRE PROTECTION <input checked="" type="checkbox"/> M P	
PROJECT BOILER/CHILLER SURVEY				
LOCATION FORT SILL		PROJECT NUMBER		
CMT. NO.	DWG. NO. OR REF.	REVIEWER SERGE SALTIEL	PHONE NUMBER (405) 351-4250 5708	
EXECUTIVE SUMMARY				
1.	ES 2	THIS ANALYSIS SHOULD BE INDEPENDENT OF THE EMCS. CAN NOT ASSUME THAT THE EMCS WILL BE INSTALLED		✓
2	ES 3	THIS STUDY SHOULD VALIDATE IF A CENTRAL PLANT ADDITION TO 3442 IS A GOOD PROJECT		✓
3	ES 3/4	OPERATIONAL NOTES TO SAVE ENERGY WITH LOW OR NO COST ARE TOO GENERAL.		✓
4	ES 5	STATEMENT ABOUT THE 3442 PLANT ADD. (SAME AS COMM. 2) MUST BE VALIDATED TO SEE IF WE SHOULD INCLUDE IN THE BRKS PROJECT.		✓
5	ES 8	ECO LIST SHOWS 17 ITEMS DESCRIPTIONS ARE NOT CLEAR EXAMPLE: #1 & 7. HOW IS ESTABLISHING CHILLER & BOILER LOAD GOING TO SAVE ENERGY?		✓

PAGE 1 OF

L 836 Army—Fort Sill, Okla.

FORT SILL REVIEW COMMENTS			DATE 17 JUL 91	ACTION	
DIRECTORATE OF ENGINEERING & HOUSING			DISCIPLINE  <input type="checkbox"/> CIVIL <input type="checkbox"/> ARCHITECTURAL <input type="checkbox"/> MECHANICAL <input type="checkbox"/> ELECTRICAL <input type="checkbox"/> FIRE PROTECTION <input checked="" type="checkbox"/> MP	A CONCUR D DO NOT CONCUR E EXCEPTION X DELETE (EXPLAIN D, E, & X)	
PROJECT BOILER/CHILLER SURVEY				ACTION BY	
LOCATION FORT SILL		PROJECT NUMBER	PHONE NUMBER (405) 351-4250	COMPLY _____	
CMT. NO.	DWG. NO. OR REF.	REVIEWER			
6	ES10	ECO NO 8 FOR BLDG 730 SHOWS AN SIR OF 2.2 & A PAYBACK OF 8 YEARS, HOWEVER ON TABLE ES-7 (PAGE ES21) THE SAME ECO IS SHOWN AS NOT FEASIBLE.	WILL CORRECT TABLE ES-4 PAGEES 10 ✓		
7	ES18/19	NEGATIVE PAYBACK YEARS IS MEANINGLESS. <i>NA</i>	✓		
8		GENERAL COMMENT. THE EXECUTIVE SUMMARY MUST RELATE THE OVERALL FINDINGS OF THE SURVEY, HOWEVER IT MUST CONTAIN SPECIFIC DESCRIPTION OF EACH RECOMMENDATION FOR THE "EXECUTIVE" TO MAKE DECISIONS WITHOUT GOING THROUGH THE BACK-UP REPORTS. RECOMMENDATIONS ARE VERY GENERAL & PROPOSED SCOPE OF PROJECTS TOO HARD TO FOLLOW.	✓		

PAGE 2 OF       

L 836 Army—Fort Sill, Okla.

FORT SILL REVIEW COMMENTS		DATE	ACTION
		8 July, 1991	
DIRECTORATE OF ENGINEERING & HOUSING		DISCIPLINE	A CONCUR
		CIVIL	D DO NOT CONCUR
ENERGY SURVEY OF ARMY BOILER & CHILLER PLANTS		ARCHITECTURAL	E EXCEPTION
		XX MECHANICAL	X DELETE
LOCATION	PROJECT NUMBER	ELECTRICAL	(EXPLAIN D, E & X)
FORT SILL, OKLAHOMA	DACA 56-90-C-0087	FIRE PROTECTION	
		PHONE NUMBER	ACTION BY
CMT. DWG. REVIEWER		(405)351-4250	COMPLY
NO. NO.	JERRY SCHMIDT		

# VOLUME 1

1. 2-19 Paragraph 2.2.4  
The chillers in central plant building 3442 serves a total of 21 buildings. ✓
2. 2-34 Paragraph 2.2.8 and Paragraph 2.2.8.2  
The central plant building 5900 serves a total of 5 barracks (bldgs. no. 5955, 5960, 5970, 6007 & 6050). ✓
3. 2-45 Central plant chiller should be 370 tons Table 2-2 shows chiller to be 170 tons. ✓
4. 2-46 Central plant (No. 5676) chiller should be 375 tons Table 2-2 shows chiller to be 170 tons. VERIFY
5. 3-2 The distribution loss for the area served by the central plant in building have been more than negligible. The heat loss from the super heated hot water distribution system have caused sufficient ground heating to damaged some of the chilled water piping. If the ground heat was sufficient to cause damage to plastic piping systems then it stands to reason that the losses are more than negligible. *Ground temp 155F w/boilers on.* VERIFY FOR HTH  
✓ DISREGARD FOR CHW
6. Tab 4 Annual savings for Ice Storage Systems was based on 12 months per year and the existing chiller efficiency. The use of Air Conditioning is only authorized 4 to 5 months per year and the existing chillers, modified to produce ice, will lose efficiency. The savings should be based on the actual period of use and the efficiency achieved while producing ice. NA
7. 4-47 The estimated construction cost to replace the existing gas chiller appears to be excessive. NA
8. 6-5 The chiller located at central plant 914 is a 400 ton chiller. ✓
9. 6-13 The central plant 6003 has three chillers one 400 ton and two 450 ton chillers. The operational strategies only addressed using the two 450 ton chillers. ✓

L 836 Army-Fort Sill, Okla.

FORT SILL REVIEW COMMENTS		DATE	8 July, 1991	ACTION
DIRECTORATE OF ENGINEERING & HOUSING		DISCIPLINE		A CONCUR
ENERGY SURVEY OF ARMY BOILER & CHILLER PLANTS		CIVIL		D DO NOT CONCUR
LOCATION		ARCHITECTURAL		E EXCEPTION
FORT SILL, OKLAHOMA		XX MECHANICAL		X DELETE
PROJECT NUMBER		ELECTRICAL		(EXPLAIN D, E & X)
DACA 56-90-C-0087		FIRE PROTECTION		
CMT. DWG. REVIEWER		PHONE NUMBER		ACTION BY
NO. NO. JERRY SCHMIDT		(405)351-4250		COMPLY

- |                          |  |   |
|--------------------------|--|---|
| 10. 7-2                  | Brief description on ECO would be beneficial at this point.  | ✓ |
| <u>VOLUME II</u>         |  |   |
| 11. C-3                  | Building 5900 chiller 4 should be listed as a 450 ton chiller.   | ✓ |
| <u>EXECUTIVE SUMMARY</u> |  |   |
| 12.                      | The executive summary should have included recommendation concerning the CFC issue. The base has a large number of chillers that would be affected by CFC legislation. | ✓ |

## CONFIRMATION NOTICE

Confirmation No. 4

EMC #3002.000

DATE: 19 August 1991

PROJECT: Energy Survey of Central Plants, Ft. Sill, Oklahoma  
CONTRACT NO.: DACA56-90-C-0087

NOTES

PREPARED BY: Carl Lundstrom  
E M C Engineers, Inc.

DATE OF  
CONFERENCE: 15 August 1991

PLACE OF  
CONFERENCE: Tulsa District Resident Engineer's Office

SUBJECT: Interim Review Conference Presentation and Comments Review

ATTENDEES: W. Wayne Kiser, DEH (405) 351-5708  
Merle London, Tulsa District COE (918) 581-7991  
Carl E. Lundstrom, EMC Engineers, Inc. (404) 952-3697  
Gene Paulsgrove, DEH Master Planning (405) 351-5708  
Kenneth Rogers, DEH (405) 351-5910  
Serge Saltiel, DEH (405) 351-5708  
Jerry Schmidt, DEH Engr. Design (405) 351-4250  
Carl Swenson, EMC Engineers (303) 988-2951

The following is a summary of the items discussed, the comments made, and the decisions made during the Conference:

1. Mr. London made introductions and passed roster to attendees.
2. Mr. Lundstrom made a presentation of the Interim Submittal:
  - Survey Findings.
  - ECO Analysis.
  - Conclusions and Recommendations.

Based on the discussion of the presentation, the following items were concluded and project direction was determined:

CONFIRMATION NO. 4

19 August 1991

Page 2

- Review electrical rates to verify electric demand rate charges.
- ECO 3, Central Plant 914, repair chiller to increase efficiency: This ECO has been done under warranty service.
- ECO 4, Central Plant 914, ice storage: This ECO was rejected; savings are marginal.
- ECO 3, Central Plant 2812, replace chiller: This ECO was not economically justified as a replacement project. To repair the existing chiller is not an acceptable alternative.
- ECO 17, Central Plants 730 and 2812, electric water heaters: This ECO was rejected, because Ft. Sill does not want to do any projects which may increase the Fort's overall summer electrical demand.
- ECO 3, Central Plant 4701, replace chiller: This ECO was not economically justified as a replacement project. To repair the existing chillers is not an acceptable alternative.
- ECO 4, Central Plant 4701, ice storage: This ECO was rejected because of marginal savings.
- RDF boiler, Central Plant 5900: This special project to update a previous study was rejected because of current refuse quantities and operation of the plant.
- ECO 9, Central Plant 5900, replace boilers: This ECO will be investigated in place of the proposed repair project.
- ECO 12, Central Plant 5900, stack economizers: This ECO was rejected because of the potential increase in manpower to support operations.
- Central Plant 3442, service extension to provide cooling to Buildings 2470 and 2471: This special project is not required because these two buildings have new chiller equipment.
- ECO 6, high efficiency motors, all plants: In place of further analysis, it should be noted that high efficiency motors should be installed if replacements are justified.
- ECO 10, boiler combustion controls, all plants: No further analysis or consideration is required, because of the concern regarding the marginal savings and high maintenance requirements.

3. The Ft. Sill DEH engineers conferred as to proposed ECOs to develop into projects for the final submittal.

Based on their discussion, the following projects were developed:

Project A:

Boiler and chiller controls project (ECOs 1, 2, 7, and 8) for Central Plants 730, 914, 2812, 3442, 5676, 5678, 5900, and 6003. The control project is to be a stand-alone project, and the savings or costs should not assume an EMCS exists.

Project B:

Central heating plant replacement project at Central Plant 5900, boilers 1 and 2, and Central Plant 2812, boilers 1 and 2.

Project C:

One new central plant to provide heating and cooling to both Buildings 5676 and 5678.

In preparing the final analysis, Ft. Sill DEH engineers requested the energy analysis be based on the assumption the EMCS was not installed. Mr. Lundstrom agreed to use non-EMCS loads to prepare the final analysis. The Ft. Sill DEH engineers asked that the computer input for the final project energy analysis be included with the final report. Mr. Lundstrom agreed to provide this information.

4. Additional analysis comparison:

- Compare central heating plant at 3442, to individual boilers at each building. Consider plant to also serve Buildings 2470 and 2471. Do not consider using chilled water lines for distribution from heating plant.



Carl E. Lundstrom  
/rt

If any portion of this Confirmation Notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 10 days, it will be assumed that the decisions and conclusions, and status outlined in this Confirmation Notice is correct.

## CONFERENCE NOTICE

EMC #3002.000

Conformation No. 5

DATE: 10 September 1991

PROJECT: Energy Survey of Army Boiler and Chiller Plants Ft. Sill, Oklahoma  
CONTRACT No. DACA 56-90-C-0087

NOTICE  
PREPARED BY: Kamchornvuthi Chulavatr  
E M C Engineers, Inc.

DATE OF  
CONFERENCE: 6 September 1991

PLACE  
OF CONFERENCE: Public Work Center, Mr. Howard Hovis office, Ft. Sill, Oklahoma

SUBJECT: To discuss central plant's control strategy and projects to be evaluated in the study

ATTENDEES: W. Wayne Keiser, DEH, Ft. Sill (405) 351-5708  
Serge Saltiel, DEH, Ft. Sill (405) 351-5708  
Jerry Schmidt, DEH, Ft. Sill, (405) 351-4250  
Howard Hovis, PWC, Ft. Sill, (405) 351-3608/5341  
Kamchornvuthi Chulavatr, E M C Engineers, Inc., (404) 952-3697

The following is a summary of the items discussed, the comments made, and the decisions made during the conference.

The control and monitoring points for central plants will include the following:

- |               |   |
|---------------|---|
| <u>Boiler</u> | <ul style="list-style-type: none"><li>- Natural gas line pressure before and after the regulator</li><li>- Flow and accumulative of the make-up water</li><li>- Boiler stack temperature and O<sub>2</sub></li><li>- Boilers alarm</li><li>- Pumps start/stop and status</li><li>- Supply and return water temperatures</li><li>- Flow of the supply steam and hot water</li><li>- Supply pressure for steam and nitrogen in the expansion tank for high temperature hot water</li><li>- LEDs display</li></ul> |
|---------------|---|

CONFERENCE NOTICE  
10 September 1991  
Page 2

- Chiller
- Pumps start/stop and status
  - Supply and return chilled water and condenser water temperatures
  - Flow of the chilled water
  - Chiller start/stop and status
  - Cooling towers start/stop and status
  - Chiller kW consumption
  - LEDs display

Projects to be evaluated are:

- Project 1. - Control project for central plant 730, 5900, and 6003.
- Project 2. - Central plant project and control project for building 5676 and 5678.
- Project 3. - Replace boiler number 1 and 2 in central plant 2812 and 5900.
- Project 4. - Replace a chiller in central plant 2812 with the small higher efficiency chiller.
- Project 5. - Compare local hot water boiler in each barracks versus central heating plant project for 3442.

The following are result of general item discussed:

- The control project will include the fiber optics DTM cost from the central plant to RVAC shop, building 1950.
- There will not be any new control projects for central plant 914, 2812, and cooling plant 3442.
- The central computer for the control project will be an existing PC located in the RVAC shop, and, if possible, use existing software.

  
Kamchornvuthi Chulavatr

If any portion of this conformation notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions and conclusions, and status outlined in this notice are correct.

## CONFIRMATION NOTICE

EMC# 3002.000

Confirmation No. 6

DATE: 9 March 1992

PROJECT: Energy Survey of Army Boiler and Chiller Plants  
Ft. Sill, Oklahoma

CONTRACT NO: DACA56-90-C-0087

NOTES  
PREPARED BY: Carl E. Lundstrom  
EMC Engineers, Inc.

DATE OF  
CONFERENCE: 5 March 1992

PLACE OF  
CONFERENCE: Mr. Kiser's Office, Dept. of Public Works  
Ft. Sill, OK

SUBJECT: To discuss results of the Prefinal report.

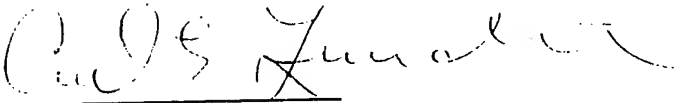
ATTENDEES: Carl Lundstrom, EMC Engineers, Inc. (404) 952-3697  
Merle London, Tulsa District COE (918)-581-7991  
Jerry Schmidt, Ft. Sill DPW, Engineering Design (405)-351-4250  
Howard Hovis, Ft. Sill DPW, Chief FMD, (405) 351-3608  
Gene Paulsgrove, Ft. Sill DPW, Planning, (405) 351-5708  
W. Wayne Kiser, Ft. Sill DPW, Chief Engineering Division, (405) 351-5708

The following is a summary of the items discussed, the comments made, and the decisions made during the conference:

1. Mr. Lundstrom explained EMC finished and submitted the Prefinal report in October 1991.
2. Mr. Lundstrom reviewed the results of the evaluation of the five projects developed from the Interim Submittal.
3. Mr. Lundstrom went over the review comments made by Jerry Schmidt. Mr. Lundstrom confirmed he would make the following revisions to the final submittal:
  - o Distribution losses for chilled water lines will be included in the project energy calculations for Central Plants 6003 and 5900.

Confirmation No. 6  
9 March 1992  
Page 2

- o Project 2: (Central Plants 5676 and 5678) will be reviewed as a heating plant replacement project only, with the idea of chiller plant replacement in the future.
- o Comments regarding Project 4 are not applicable, since the chiller is being replaced under a current construction project.



Carl E. Lundstrom, P.E.

If any portion of this confirmation notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions and conclusions, and status outlined in this confirmation notice are correct.

SILL REVIEW COMMENTS		DATE	ACTION
		6 November, 1991	
=====			
DIRECTORATE OF PUBLIC WORKS		DISCIPLINE	A CONCUR
=====		CIVIL	D DO NOT CONCUR
ENERGY SURVEY OF ARMY BOILER & CHILLER PLANTS		ARCHITECTURAL	E EXCEPTION
=====		XX MECHANICAL	X DELETE
LOCATION	PROJECT NUMBER	ELECTRICAL	(EXPLAIN D, E & X)
FORT SILL, OKLAHOMA	DACA 56-90-C-0087	FIRE PROTECTION	
=====			ACTION BY
CMT. DWG. REVIEWER		PHONE NUMBER	
NO. NO.	JERRY SCHMIDT	(405)351-4250	
=====			

#### VOLUME I

1. 3-2 The distribution loss for the area served by the central plant in building 5900 and 6003 have been more than negligible. The heat loss from the super heated hot water and steam distribution systems have caused sufficient ground heating to damaged some of the chilled water piping; by causing ovaling, blistering and collapse of the plastic chilled water piping. If the ground heat was sufficient to cause damage to plastic piping systems then it stands to reason that the losses are more than negligible.

A

#### 2. Section 6, paragraph 6.2.1

The Central Plant at building 730 has three CHILLERS, two 300 tons and one 800 tons. Chiller Optimization should utilize all three chillers. For low load conditions of 0 to 300 tons, one 300 tons chiller. Medium load of 300 to 600 tons, two 300 tons chillers. High load of 600 to 800 tons, one 800 tons chiller. Peak load of 800 tons and above, one 800 tons and one 300 tons chillers. This strategy will have the chillers operating at 70 to 80 percent of there peak capacity (the most economical portion of there efficiency curve) the majority of there operating time.

A

#### 3. Section 8, paragraph 8.1.2

The difference in cost of a central plant and replacing the existing equipment is what should be compared.

X

#### VOLUME II

4. C-3 (Reference Review Comment number 11 dated 8 July 1991.)

Building 5900 chiller 4 should be listed as a 450 ton chiller.

A

#### VOLUME III

5. J.1.8 The drawing indicates that there may be adequate space in the existing mechanical room for the heating and cooling equipment, if one chiller is used, thus eliminated the need for the addition to the building.

X

L 836 Army-Fort Sill, Okla.

SILL REVIEW COMMENTS		DATE	ACTION
		6 November, 1991	
=====			
DIRECTORATE OF PUBLIC WORKS	DISCIPLINE		A CONCUR
	CIVIL		D DO NOT CONCUR
ENERGY SURVEY OF ARMY BOILER & CHILLER PLANTS	ARCHITECTURAL		E EXCEPTION
	XX MECHANICAL		X DELETE
LOCATION	ELECTRICAL		(EXPLAIN D, E & X)
FORT SILL, OKLAHOMA	FIRE PROTECTION		
=====			
CMT. DWG. REVIEWER	PHONE NUMBER		ACTION BY
NO. NO. JERRY SCHMIDT	(405)351-4250		-----
=====			

6. J.1.4 & J.1.5

If the scope is reduced from two chillers to one chiller and eliminating the addition to the building the project bare cost could be reduces approximately \$200,000.  
(Building addition \$120,000 Chiller \$80,000)

A

7. L.1.4 If the chiller sizing is based on the combined load of the connected buildings (Reference Volume II page B-5) 305.7 Tons and a diversity factor of 0.85 used the chiller size should be 260 Tons. This down sizing of the chiller from 342 Tons to 260 Tons should increase the energy savings and lower the cost of the chiller without altering the comfort level in the buildings.

X

**APPENDIX B**

**BASE LOAD DATA  
AND MISCELLANEOUS CALCULATIONS**

**HEATING AND COOLING LOADS  
OF  
REPRESENTATIVE BUILDINGS**

# REPRESENTATIVE BUILDING INFORMATION

11-Apr-91

XXX = BUILDING TYPE WITH EMCS  
XXX-N = BUILDING TYPE WITHOUT EMCS

MONTH	BLDG. TYPE	BARRACK	BARRACK-N	OFFICE	OFFICE-N	CLUB	CLUB-N
	BLDG. NO	3411	3411	3161	3161	3281	3281
	SQ. FT	8246	8246	6500	6500	27526	27526
JANUARY	PEAK LIGHTING (KW)	27	27	2	2	34	34
	PEAK HEATING (BTU/H)	3.59E+05	3.66E+05	1.46E+05	1.49E+05	9.28E+05	9.28E+05
	PEAK COOLING (BTU/H)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HEATING (MBTU)	216.00	235.00	45.29	74.96	316.00	441.00
	COOLING (T-kWH)	0.00	0.00	0.00	0.00	0.00	0.00
FEBRUARY	LIGHTING (KWH)	9.54	9.54	0.63	0.63	14.65	14.65
	PROCESS (MBTU)	1.70	1.70	3.28	3.28	127.12	127.12
	PEAK HEATING (BTU/H)	3.12E+05	3.25E+05	1.27E+05	1.32E+05	8.06E+05	8.06E+05
	PEAK COOLING (BTU/H)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HEATING (MBTU)	147.00	166.00	30.03	53.64	205.00	298.00
MARCH	COOLING (T-kWH)	0.00	0.00	0.00	0.00	0.00	0.00
	LIGHTING (KWH)	8.61	8.61	0.55	0.55	13.23	13.23
	PROCESS (MBTU)	1.53	1.53	2.86	2.86	114.82	114.82
	PEAK HEATING (BTU/H)	3.25E+05	3.39E+05	1.32E+05	1.38E+05	8.41E+05	8.41E+05
	PEAK COOLING (BTU/H)	3.99E+04	6.30E+04	1.59E+04	1.59E+04	2.02E+05	1.05E+05
APRIL	HEATING (MBTU)	100.00	119.00	19.32	38.04	125.00	195.00
	COOLING (T-kWH)	0.09	0.34	0.00	0.07	1.63	2.39
	LIGHTING (KWH)	9.54	9.54	0.61	0.61	14.65	14.65
	PROCESS (MBTU)	1.70	1.70	3.14	3.14	127.12	127.12
	PEAK HEATING (BTU/H)	2.44E+05	2.57E+05	9.91E+04	1.05E+05	6.31E+05	6.31E+05
MAY	PEAK COOLING (BTU/H)	1.32E+05	1.49E+05	3.55E+04	3.49E+04	2.76E+05	2.32E+05
	HEATING (MBTU)	10.11	13.96	3.01	8.56	11.00	28.00
	COOLING (T-kWH)	1.23	2.35	0.16	0.45	6.77	9.05
	LIGHTING (KWH)	9.23	9.23	0.58	0.58	14.18	14.18
	PROCESS (MBTU)	1.64	1.64	3.00	3.00	123.01	123.01
JUNE	PEAK HEATING (BTU/H)	0.00E+00	0.00E+00	4.68E+04	8.25E+04	2.98E+05	2.98E+05
	PEAK COOLING (BTU/H)	1.63E+05	1.77E+05	5.68E+04	4.17E+04	4.77E+05	2.93E+05
	HEATING (MBTU)	0.00	1.27	0.30	1.58	1.00	1.69
	COOLING (T-kWH)	4.43	6.45	0.61	1.33	15.45	20.06
	LIGHTING (KWH)	9.54	9.54	0.63	0.63	14.65	14.65
	PROCESS (MBTU)	1.70	1.70	3.28	3.28	127.12	127.12
	PEAK HEATING (BTU/H)	0.00E+00	0.00E+00	3.85E+04	3.85E+04	0.00E+00	0.00E+00
	PEAK COOLING (BTU/H)	1.96E+05	2.07E+05	1.17E+05	5.25E+04	5.82E+05	3.44E+05
	HEATING (MBTU)	0.00	0.00	0.03	0.61	0.00	0.00
	COOLING (T-kWH)	11.55	13.25	1.66	3.20	27.30	35.86
	LIGHTING (KWH)	9.23	9.23	0.58	0.58	14.18	14.18
	PROCESS (MBTU)	1.64	1.64	3.00	3.00	123.01	123.01

# REPRESENTATIVE BUILDING INFORMATION

11 - Apr - 91

XXX = BUILDING TYPE WITH EMCS  
XXX-N = BUILDING TYPE WITHOUT EMCS

MONTH	BLDG. TYPE	BARRACK	BARRACK-N	OFFICE	OFFICE-N	CLUB	CLUB-N
JULY	BLDG. NO	3411	3411	3161	3161	3281	3281
	SQ. FT	8246	8246	6500	6500	27526	27526
	PEAK LIGHTING (KW)	27	27	2	2	34	34
	PEAK HEATING (BTU/H)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.30E+01
	PEAK COOLING (BTU/H)	1.98E+05	2.07E+05	1.17E+05	5.02E+04	5.82E+05	4.23E+05
	HEATING (MBTU)	0.00	0.00	0.00	0.00	0.00	0.00
	COOLING (T - KWH)	13.99	15.64	2.16	3.97	33.07	43.04
	LIGHTING (KWH)	9.54	9.54	0.61	0.61	14.65	14.65
	PROCESS (MBTU)	1.70	1.70	3.14	3.14	127.12	42.95
	PEAK HEATING (BTU/H)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AUGUST	PEAK COOLING (BTU/H)	2.07E+05	2.07E+05	1.17E+05	4.94E+04	5.82E+05	4.21E+05
	HEATING (MBTU)	0.00	0.00	0.00	0.00	0.00	0.00
	COOLING (T - KWH)	14.15	15.77	2.02	3.89	32.57	42.95
	LIGHTING (KWH)	9.54	9.54	0.63	0.63	14.65	15.00
	PROCESS (MBTU)	1.70	1.70	3.28	3.28	127.12	127.12
	PEAK HEATING (BTU/H)	0.00E+00	0.00E+00	3.30E+04	3.03E+04	2.10E+05	2.10E+05
	PEAK COOLING (BTU/H)	1.91E+05	2.04E+05	1.17E+05	4.72E+04	5.82E+05	3.92E+05
	HEATING (MBTU)	0.00	0.00	0.19	1.13	0.00	1.00
	COOLING (T - KWH)	9.17	10.95	1.20	2.40	22.21	29.12
	LIGHTING (KWH)	9.23	9.23	0.56	0.56	14.18	14.18
OCTOBER	PROCESS (MBTU)	1.64	1.64	2.87	2.87	123.01	123.01
	PEAK HEATING (BTU/H)	1.22E+05	2.17E+05	4.95E+04	8.80E+04	3.15E+05	3.15E+05
	PEAK COOLING (BTU/H)	1.84E+05	1.98E+05	8.02E+04	3.76E+04	5.77E+05	3.51E+05
	HEATING (MBTU)	0.17	3.47	5.51	8.66	8.00	20.00
	COOLING (T - KWH)	1.91	3.39	0.20	0.56	7.70	10.94
	LIGHTING (KWH)	9.54	9.54	0.63	0.63	14.65	14.65
	PROCESS (MBTU)	1.70	1.70	3.28	3.28	127.12	127.12
	PEAK HEATING (BTU/H)	2.10E+05	2.24E+05	8.53E+04	9.08E+04	5.43E+05	5.43E+05
	PEAK COOLING (BTU/H)	0.00E+00	3.52E+04	0.00E+00	0.00E+00	1.33E+05	1.54E+05
	HEATING (MBTU)	63.00	78.00	15.62	32.13	84.00	142.00
NOVEMBER	COOLING (T - KWH)	0.00	0.04	0.00	0.00	0.35	0.77
	LIGHTING (KWH)	9.23	9.23	0.61	0.61	14.18	14.18
	PROCESS (MBTU)	1.64	1.64	3.14	3.14	123.01	123.01
	PEAK HEATING (BTU/H)	2.85E+05	2.98E+05	1.16E+05	1.21E+05	7.36E+05	7.36E+05
	PEAK COOLING (BTU/H)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HEATING (MBTU)	154.00	174.00	33.75	62.31	225.00	337.00
	COOLING (T - KWH)	0.00	0.00	0.00	0.00	0.00	0.00
	LIGHTING (KWH)	9.54	9.54	0.58	0.58	14.65	14.65
	PROCESS (MBTU)	1.70	1.70	3.01	3.01	127.12	127.12
	PEAK HEATING (BTU/H)	2.85E+05	2.98E+05	1.16E+05	1.21E+05	7.36E+05	7.36E+05
DECEMBER	PEAK COOLING (BTU/H)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HEATING (MBTU)	154.00	174.00	33.75	62.31	225.00	337.00
	COOLING (T - KWH)	0.00	0.00	0.00	0.00	0.00	0.00
	LIGHTING (KWH)	9.54	9.54	0.58	0.58	14.65	14.65
	PROCESS (MBTU)	1.70	1.70	3.01	3.01	127.12	127.12
	PEAK HEATING (BTU/H)	2.85E+05	2.98E+05	1.16E+05	1.21E+05	7.36E+05	7.36E+05
	PEAK COOLING (BTU/H)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HEATING (MBTU)	154.00	174.00	33.75	62.31	225.00	337.00
	COOLING (T - KWH)	0.00	0.00	0.00	0.00	0.00	0.00
	LIGHTING (KWH)	9.54	9.54	0.58	0.58	14.65	14.65

**BUILDING SERVED BY CENTRAL PLANT  
AND THEIR PEAK HEATING/COOLING**

# **BUILDING CONNECTED TO CENTRAL PLANT**

11-Apr-91

Energy Plant	Bldg Number	Bldg Name	Bldg use	Bldg SF	Bldg MBH	Bldg ton	Similar Bldg	Ratio of Sq. Ft
5900 *	6007	BARRACK	BARRACK OFFICE CLUB	189290 18945 12520	8.97	383.0	3411 3161 3281	22.96 2.91 0.45
	6050	BARRACK	BARRACK OFFICE CLUB	189290 18945 12520	7.47	383.0	3411 3161 3281	22.96 2.91 0.45
	5955	BARRACK	BARRACK OFFICE CLUB	189290 18945 12520	7.47	383.0	3411 3161 3281	22.96 2.91 0.45
	5960	BARRACK	BARRACK OFFICE CLUB	189290 18945 12520	7.47	383.0	3411 3161 3281	22.96 2.91 0.45
	5970	BARRACK	BARRACK OFFICE CLUB	189290 18945 12520	7.47	383.0	3411 3161 3281	22.96 2.91 0.45
	5900	ENERGY PLT	BARRACK	1500	3.03	0.0	3411	0.18
	<b>ENERGY PLANT TOTAL</b>				42	1915	22.98	
	6002	ADMINIS.	OFFICE - N	23671	0.44	19.0	3161	3.64
	6003	ENERGY PLT	BARRACK	0	0.40	0.0	3411	0.00
	6004	ADMINIS.	OFFICE - N	23671	0.44	19.0	3161	3.64
6003 *	6009	BARRACK	BARRACK - N	34872	1.71	76.0	3411	4.23
	6010	BARRACK	BARRACK - N	34872	1.71	76.0	3411	4.23
	6011	MESS HALL	CLUB	17121	4.64	134.0	3281	0.62
	6012	BARRACK	BARRACK - N	78121	1.71	152.0	3411	9.47
	6014	BARRACK	BARRACK - N	34872	1.71	76.0	3411	4.23
	6015	BARRACK	BARRACK - N	34872	1.71	76.0	3411	4.23
	6017	BARRACK	BARRACK - N	69744	0.52	46.0	3411	8.46
	6018	BARRACK	BARRACK - N	69744	1.71	152.0	3411	8.46
	6120	CLASSROOM	OFFICE	15988	0.91	30.0	3161	2.46
	6080	STORE HS.	OFFICE - N	1372	0.16	32.0	3161	0.21
	<b>ENERGY PLANT TOTAL</b>				18	888	10.66	
730 *	700	CLASSROOM	OFFICE	146599	4.22	362.0	3161	22.55
	707	CLASSROOM	OFFICE	77010	2.22	198.0	3161	11.85
	730	CLASSROOM	OFFICE	214072	5.79	570.0	3161	32.93
	840	CLASSROOM	OFFICE	142459	2.36	0.0	3161	21.92
	<b>ENERGY PLANT TOTAL</b>				14.5918	1130	13.56	
2812	2811	MESS HALL	CLUB - N	9192	0.41	41.0	3281	0.33
	2838	BARRACK	BARRACK - N	13132	0.40	18.7	3411	1.59
	2839	BARRACK	BARRACK - N	13132	0.40	18.7	3411	1.59
	2841	BARRACK	BARRACK - N	13132	0.40	18.7	3411	1.59
	2842	BARRACK	BARRACK - N	13132	0.40	18.7	3411	1.59
	2844	BARRACK	OFFICE	13132	0.40	18.7	3161	2.02
	2845	BARRACK	OFFICE	13132	0.40	18.7	3161	2.02
	2846	BARRACK	OFFICE	13132	0.40	18.7	3161	2.02
	2847	BARRACK	BARRACK - N	13132	0.40	18.7	3411	1.59
	2854	BARRACK	BARRACK - N	13132	0.40	18.7	3411	1.59
	2856	BARRACK	BARRACK - N	13132	0.40	18.7	3411	1.59
	2857	BARRACK	BARRACK - N	13132	0.40	18.7	3411	1.59
	2858	DAY ROOM	OFFICE	12084	0.43	40.0	3161	1.86
	2859	BARRACK	BARRACK - N	13132	0.40	19.0	3411	1.59
	<b>ENERGY PLANT TOTAL</b>				5.61	305.70	3.67	

# **BUILDING CONNECTED TO CENTRAL PLANT**

11-Apr-91

Energy Plant	Bldg Number	Bldg Name	Bldg use	Bldg SF	Bldg MBH	Bldg ton	Similar Bldg	Ratio of Sq. Ft
5676 *	5676	BARRACK	BARRACK	89660.8	3.28	155.1	3411	10.87
		BARRACK	OFFICE	17932.2			3161	2.76
					3.28	155.10	1.86	
5678 *	5678	BARRACK	BARRACK	103333	3.91	201.6	3411	12.53
		BARRACK	OFFICE	20666.7			3161	3.18
					3.91	201.60	2.42	
3442 *	3411	BARRACK	BARRACK	36569	1.26	61.9	3411	4.43
	3412	BARRACK	BARRACK	36569	1.26	61.9	3411	4.43
	3413	BARRACK	BARRACK	36569	1.26	61.9	3411	4.43
	3414	BARRACK	BARRACK	36569	1.26	61.9	3411	4.43
	3415	BARRACK	BARRACK	36569	1.26	61.9	3411	4.43
	3416	BARRACK	OFFICE	36569	1.26	61.9	3161	5.63
	3417	BARRACK	OFFICE	36569	1.26	61.9	3161	5.63
	3418	BARRACK	OFFICE	36569	1.26	61.9	3161	5.63
	3419	BARRACK	OFFICE	36569	1.26	61.9	3161	5.63
	3420	BARRACK	OFFICE	36569	1.26	61.9	3161	5.63
	3421	BARRACK	OFFICE	36569	1.26	61.9	3161	5.63
	3422	BARRACK	OFFICE	36569	1.26	61.9	3161	5.63
	3423	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	3424	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	3425	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	3426	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	3427	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	3428	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	3429	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	3430	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	3440	BARRACK	BARRACK-N	36569	1.26	61.9	3411	4.43
	ENERGY PLANT TOTAL				26.38	1299.90	15.60	
914	900	BARRACK	OFFICE-N	61498	1.86	82.0	3161	9.46
	912	BARRACK	OFFICE-N	97470	2.72	120.0	3161	15.00
	913	BARRACK	OFFICE-N	96029	2.52	118.0	3161	14.77
	914	BARRACK	BARRACK	82462.5	2.86	118.0	3411	10.00
	ENERGY PLANT TOTAL				2.86	438.00	5.26	
4701 *	4700	ADMINIS.	OFFICE	197112	4.2584	423.1	3161	30.32
					4.26	423.10	5.08	

**ESTIMATED MONTHLY HEATING LOAD  
LISTED BY CENTRAL PLANT**

# MONTHLY HEATING LOADS

CENTRAL - WK3

03-Apr-92

ENERGY PLANT	MONTH	(A) PEAK HEATING (BTU/H)	(B) DISTRIB. LOSSES (BTU/H)	(C) DOMESTIC HW@80% (BTU/H)	(D) (B)+(C) (BTU/H)	(E)=(D+A) TOTAL PEAK HEATING (BTU/H)	(F) HEATING CONSUMPT (MMBTU)	(G) DISTRIB. LOSSES (MMBTU)	(H) HW LOAD (MMBTU)	(I) (B)+(C) (MMBTU)	(J)=(F+I) TOTAL HEATING (MMBTU)
730	JANUARY	14,591,800	156,400	409,862	566,262	15,158,062	6,602	116	40	156	6,758
	FEBRUARY	14,591,800	156,400	409,862	566,262	15,158,062	4,724	105	36	141	4,865
	MARCH	14,591,800	156,400	409,862	566,262	15,158,062	3,350	116	40	156	3,506
	APRIL	9,247,715	156,400	409,862	566,262	9,813,978	754	113	38	151	905
	MAY	7,266,062	156,400	409,862	566,262	7,832,324	139	116	40	156	295
	JUNE	3,390,829	156,400	409,862	566,262	3,957,091	54	113	38	151	205
	JULY	0	156,400	409,862	566,262	566,262	0	116	40	156	156
	AUGUST	0	156,400	409,862	566,262	566,262	0	116	40	156	156
	SEPTEMBER	2,668,626	156,400	409,862	566,262	3,234,889	100	113	38	151	251
	OCTOBER	7,750,466	156,400	409,862	566,262	8,316,728	763	116	40	156	919
	NOVEMBER	7,997,072	156,400	409,862	566,262	8,563,334	2,830	113	38	151	2,981
	DECEMBER	14,591,800	156,400	409,862	566,262	15,158,062	5,488	116	40	156	5,644
	TOTAL	14,591,800									
914	DESIGN	14,591,800									
	JANUARY	2,857,400	0	1,288,000	1,288,000	4,145,400	530	0	16	16	546
	FEBRUARY	2,857,400	0	1,288,000	1,288,000	4,145,400	374	0	14	14	388
	MARCH	2,857,400	0	1,288,000	1,288,000	4,145,400	268	0	16	16	284
	APRIL	579,531	0	1,288,000	1,288,000	1,867,531	31	0	15	15	47
	MAY	0	0	1,288,000	1,288,000	1,288,000	3	0	16	16	19
	JUNE	0	0	1,288,000	1,288,000	1,288,000	0	0	15	15	15
	JULY	0	0	1,288,000	1,288,000	1,288,000	0	0	16	16	16
	AUGUST	0	0	1,288,000	1,288,000	1,288,000	0	0	16	16	16
	SEPTEMBER	0	0	1,288,000	1,288,000	1,288,000	0	0	15	15	15
	OCTOBER	489,331	0	1,288,000	1,288,000	1,777,331	8	0	16	16	24
	NOVEMBER	505,116	0	1,288,000	1,288,000	1,793,116	176	0	15	15	191
	DECEMBER	2,857,400	0	1,288,000	1,288,000	4,145,400	392	0	16	16	408
	TOTAL	2,857,400									
	DESIGN	2,857,400									

# MONTHLY HEATING LOADS

CENTRAL--WK3

03-Apr-92	ENERGY PLANT	(A) MONTH	(A) PEAK HEATING (BTU/H)	(B) DISTRIB. LOSSES (BTU/H)	(C) DOMESTIC HW@80% (BTU/H)	(D) (B)+(C) (BTU/H)	(E)=(D+A) TOTAL PEAK HEATING (BTU/H)	(F) HEATING CONSUMPT (MMBTU)	(G) DISTRIB. LOSSES (MMBTU)	(H) HW LOAD (MMBTU)	(I) (B)+(C) (MMBTU)	(J)=(F+I) TOTAL HEATING (MMBTU)
2812		JANUARY	5,610,300	240,800	2,015,726	2,256,526	7,866,826	1,492	179	378	557	2,049
		FEBRUARY	5,610,300	240,800	2,015,726	2,256,526	7,866,826	1,055	162	342	504	1,558
		MARCH	5,610,300	240,800	2,015,726	2,256,526	7,866,826	747	179	378	557	1,304
		APRIL	1,860,573	240,800	2,015,726	2,256,526	4,117,100	121	173	366	539	661
		MAY	743,641	240,800	2,015,726	2,256,526	3,000,167	17	179	378	557	574
		JUNE	300,893	240,800	2,015,726	2,256,526	2,557,419	5	173	366	539	544
		JULY	14	240,800	2,015,726	2,256,526	2,256,541	0	179	378	557	557
		AUGUST	0	240,800	2,015,726	2,256,526	2,256,526	0	179	378	557	557
		SEPTEMBER	306,481	240,800	2,015,726	2,256,526	2,563,007	9	173	366	539	549
		OCTOBER	1,493,592	240,800	2,015,726	2,256,526	3,750,118	86	179	378	557	643
		NOVEMBER	1,613,745	240,800	2,015,726	2,256,526	3,870,271	550	173	366	539	1,090
		DECEMBER	5,610,300	240,800	2,015,726	2,256,526	7,866,826	1,161	179	378	557	1,719
		TOTAL	5,610,300									
3442		DESIGN	5,610,300									
		JANUARY	28,897,200	0	0	0	28,897,200	5,405	0	0	0	5,405
		FEBRUARY	28,897,200	0	0	0	28,897,200	3,818	0	0	0	3,818
		MARCH	28,897,200	0	0	0	28,897,200	2,737	0	0	0	2,737
		APRIL	5,911,000	0	0	0	5,911,000	321	0	0	0	321
		MAY	0	0	0	0	0	29	0	0	0	29
		JUNE	0	0	0	0	0	0	0	0	0	0
		JULY	0	0	0	0	0	0	0	0	0	0
		AUGUST	0	0	0	0	0	0	0	0	0	0
		SEPTEMBER	0	0	0	0	0	0	0	0	0	0
		OCTOBER	4,991,000	0	0	0	4,991,000	80	0	0	0	80
		NOVEMBER	5,152,000	0	0	0	5,152,000	1,794	0	0	0	1,794
		DECEMBER	28,897,200	0	0	0	28,897,200	4,002	0	0	0	4,002
		TOTAL	28,897,200									
		DESIGN	28,897,200									

# MONTHLY HEATING LOADS

03-Apr-92  
CENTRAL-WK3  
(J)=(F+I)

ENERGY PLANT	MONTH	(A) PEAK HEATING (BTU/H)	(B) DISTRIB. LOSSES (BTU/H)	(C) DOMESTIC HW@80% (BTU/H)	(D) (B)+(C) (BTU/H)	(E)=(D+A) TOTAL PEAK HEATING (BTU/H)	(F) HEATING CONSUMPT (MMBTU)	(G) DISTRIB. LOSSES (MMBTU)	(H) HW LOAD (MMBTU)	(I) (B)+(C) (MMBTU)	TOTAL HEATING (MMBTU)
4701	JANUARY	4,258,400	11,160	860,509	871,669	5,130,069	1,355	8	100	108	1,464
	FEBRUARY	4,258,400	11,160	860,509	871,669	5,130,069	899	7	90	98	996
	MARCH	4,258,400	11,160	860,509	871,669	5,130,069	578	8	100	108	686
	APRIL	2,965,508	11,160	860,509	871,669	3,837,176	90	8	97	105	195
	MAY	1,400,462	11,160	860,509	871,669	2,272,131	9	8	100	108	117
	JUNE	1,152,089	11,160	860,509	871,669	2,023,758	1	8	97	105	106
	JULY	0	11,160	860,509	871,669	871,669	0	8	100	108	108
	AUGUST	0	11,160	860,509	871,669	871,669	0	8	100	108	108
	SEPTEMBER	987,505	11,160	860,509	871,669	1,859,174	6	8	97	105	110
	OCTOBER	1,481,258	11,160	860,509	871,669	2,352,926	165	8	100	108	273
	NOVEMBER	2,552,551	11,160	860,509	871,669	3,424,220	467	8	97	105	572
	DECEMBER	4,258,400	11,160	860,509	871,669	5,130,069	1,010	8	100	108	1,118
	TOTAL	4,258,400									
5676	DESIGN	4,258,400									
	JANUARY	3,278,700	0	0	0	3,278,700	780	0	0	0	780
	FEBRUARY	3,278,700	0	0	0	3,278,700	553	0	0	0	553
	MARCH	3,278,700	0	0	0	3,278,700	395	0	0	0	395
	APRIL	630,119	0	0	0	630,119	58	0	0	0	58
	MAY	224,594	0	0	0	224,594	7	0	0	0	7
	JUNE	104,811	0	0	0	104,811	2	0	0	0	2
	JULY	0	0	0	0	0	0	0	0	0	0
	AUGUST	0	0	0	0	0	0	0	0	0	0
	SEPTEMBER	82,487	0	0	0	82,487	3	0	0	0	3
	OCTOBER	532,046	0	0	0	532,046	32	0	0	0	32
	NOVEMBER	549,209	0	0	0	549,209	279	0	0	0	279
	DECEMBER	3,278,700	0	0	0	3,278,700	596	0	0	0	596
	TOTAL	3,278,700									
	DESIGN	3,278,700									

# MONTHLY HEATING LOADS

CENTRAL - WKS

03-Apr-92

ENERGY PLANT	MONTH	(A) PEAK HEATING (BTU/H)	(B) DISTRIB. LOSSES (BTU/H)	(C) DOMESTIC HW@80% (BTU/H)	(D) (B) + (C) (BTU/H)	(E) = (D+A) TOTAL PEAK HEATING (BTU/H)	(F) HEATING CONSUMPT (MMBTU)	(G) DISTRIB. LOSSES (MMBTU)	(H) HW LOAD (MMBTU)	(I) (B) + (C) (MMBTU)	(J) = (F+I) TOTAL HEATING (MMBTU)
5678	JANUARY	3,907,800	0	0	0	3,907,800	899	0	0	0	899
	FEBRUARY	3,907,800	0	0	0	3,907,800	637	0	0	0	637
	MARCH	3,907,800	0	0	0	3,907,800	456	0	0	0	456
	APRIL	726,207	0	0	0	726,207	66	0	0	0	66
	MAY	258,843	0	0	0	258,843	9	0	0	0	9
	JUNE	120,793	0	0	0	120,793	2	0	0	0	2
	JULY	0	0	0	0	0	0	0	0	0	0
	AUGUST	0	0	0	0	0	0	0	0	0	0
	SEPTEMBER	95,066	0	0	0	95,066	4	0	0	0	4
	OCTOBER	613,179	0	0	0	613,179	37	0	0	0	37
	NOVEMBER	632,959	0	0	0	632,959	321	0	0	0	321
	DECEMBER	3,907,800	0	0	0	3,907,800	687	0	0	0	687
5900	TOTAL	3,907,800									
	DESIGN	3,907,800									
	JANUARY	41,880,000	2,800,998	13,257,360	16,058,358	57,938,358	8,165	2,084	1,569	3,653	11,818
	FEBRUARY	41,880,000	2,800,998	13,257,360	16,058,358	57,938,358	5,747	1,882	1,417	3,299	9,046
	MARCH	41,880,000	2,800,998	13,257,360	16,058,358	57,938,358	4,072	2,084	1,569	3,653	7,725
	APRIL	6,661,480	0	13,257,360	13,257,360	19,918,840	548	0	1,518	1,518	2,066
	MAY	1,186,399	0	13,257,360	13,257,360	14,443,759	0	0	1,569	1,569	1,569
	JUNE	553,653	939,251	13,257,360	14,196,611	14,750,264	0	676	1,518	2,195	2,195
	JULY	97	0	13,257,360	13,257,360	13,257,457	0	0	1,569	1,569	1,569
	AUGUST	0	0	13,257,360	13,257,360	13,257,360	0	0	1,569	1,569	1,569
	SEPTEMBER	474,499	0	13,257,360	13,257,360	13,731,859	0	0	1,518	1,518	1,518
	OCTOBER	5,621,227	0	13,257,360	13,257,360	18,878,587	260	0	1,569	1,569	1,829
5900	NOVEMBER	5,806,005	2,800,998	13,257,360	16,058,358	21,864,363	2,804	2,017	1,518	3,535	6,339
	DECEMBER	41,880,000	2,800,998	13,257,360	16,058,358	57,938,358	6,167	2,084	1,569	3,653	9,820
	TOTAL	41,880,000									
5900	DESIGN	41,880,000									
	DESIGN	41,880,000									

# MONTHLY HEATING LOADS

CENTRAL - WK3

03-Apr-92	ENERGY PLANT	MONTH	(A) PEAK HEATING (BTU/H)	(B) DISTRIB. LOSSES (BTU/H)	(C) DOMESTIC HW@80% (BTU/H)	(D) (B)+(C) (BTU/H)	(E)=(D+A) TOTAL PEAK HEATING (BTU/H)	(F) HEATING CONSUMPT (MMBTU)	(G) DISTRIB. LOSSES (MMBTU)	(H) HW LOAD (MMBTU)	(I) (B)+(C) (MMBTU)	(J)=(F+I) TOTAL HEATING (MMBTU)
	6003	JANUARY	17,770,000	975,451	5,064,000	6,039,451	23,809,451	3,304	726	682	1,408	4,711
		FEBRUARY	17,770,000	975,451	5,064,000	6,039,451	23,809,451	2,332	656	616	1,271	3,604
		MARCH	17,770,000	975,451	5,064,000	6,039,451	23,809,451	1,656	726	682	1,408	3,064
		APRIL	3,930,934	722,183	5,064,000	5,786,183	9,717,117	238	520	660	1,180	1,418
		MAY	994,528	722,183	5,064,000	5,786,183	6,780,711	29	537	682	1,219	1,248
		JUNE	378,173	722,183	5,064,000	5,786,183	6,164,356	6	520	660	1,180	1,186
		JULY	27	722,183	5,064,000	5,786,183	5,786,210	0	537	682	1,219	1,219
		AUGUST	0	722,183	5,064,000	5,786,183	5,786,183	0	537	682	1,219	1,219
		SEPTEMBER	427,402	722,183	5,064,000	5,786,183	6,213,585	12	520	660	1,180	1,192
		OCTOBER	3,178,067	722,183	5,064,000	5,786,183	8,964,250	131	537	682	1,219	1,351
		NOVEMBER	3,414,824	975,451	5,064,000	6,039,451	9,454,275	1,165	702	660	1,362	2,527
		DECEMBER	17,770,000	975,451	5,064,000	6,039,451	23,809,451	2,519	726	682	1,408	3,927
		TOTAL	17,770,000									
		DESIGN	17,770,000									

**ESTIMATED MONTHLY COOLING LOAD  
LISTED BY CENTRAL PLANT**

# MONTHLY COOLING LOADS

06-Apr-92 ENERGY PLANT 730 (A) PEAK COOLING (BTU/H) (B) = (A\*0.8) PEAK W/80% DIVERSITY (BTU/H) (C) COOLING CONSUMPT. (1000kWH) (D) = C\*1000\*3413/1,000,000

MONTH	PEAK COOLING (BTU/H)	PEAK W/80% DIVERSITY (BTU/H)	COOLING CONSUMPT. (1000kWH)	COOLING CONSUMPT. (MMBTU)
JANUARY	0	0	0	0
FEBRUARY	0	0	0	0
MARCH	1,402,260	1,121,808	6	21
APRIL	3,073,411	2,458,729	40	135
MAY	3,669,513	2,935,611	117	400
JUNE	13,560,000	10,848,000	282	962
JULY	13,560,000	10,848,000	350	1,193
AUGUST	13,560,000	10,848,000	343	1,169
SEPTEMBER	13,560,000	10,848,000	211	721
OCTOBER	3,308,239	2,646,591	49	168
NOVEMBER	0	0	0	0
DECEMBER	0	0	0	0
TOTAL	13,560,000			
DESIGN	13,560,000			
JANUARY	0	0	0	0
FEBRUARY	0	0	0	0
MARCH	758,406	606,725	3	12
APRIL	1,685,942	1,348,754	23	78
MAY	2,012,044	1,609,635	66	225
JUNE	5,256,000	4,204,800	154	525
JULY	5,256,000	4,204,800	189	645
AUGUST	5,256,000	4,204,800	186	635
SEPTEMBER	5,256,000	4,204,800	118	401
OCTOBER	1,901,149	1,520,919	29	100
NOVEMBER	79,417	63,533	0	0
DECEMBER	0	0	0	0
TOTAL	5,256,000			
DESIGN	5,256,000			

# MONTHLY COOLING LOADS

06-Apr-92		(B) = (A*0.8)		(C)		(D) = C*1000*3413/1,000,000	
ENERGY PLANT	MONTH	PEAK COOLING (BTU/H)	PEAK W/80% DIVERSITY (BTU/H)	COOLING CONSUMPT. (1000kWH)	COOLING CONSUMPT. (MMBTU)		
2812	JANUARY	0	0	0	0		
	FEBRUARY	0	0	0	0		
	MARCH	362,934	290,347	2	8		
	APRIL	829,961	663,968	14	48		
	MAY	994,775	795,820	38	129		
	JUNE	3,668,400	2,934,720	80	272		
	JULY	3,668,400	2,934,720	96	327		
	AUGUST	3,668,400	2,934,720	96	326		
	SEPTEMBER	3,668,400	2,934,720	64	218		
	OCTOBER	1,050,627	840,502	19	65		
	NOVEMBER	164,994	131,996	0	1		
	DECEMBER	0	0	0	0		
	TOTAL		3,668,400				
3442	DESIGN						
	JANUARY	0	0	0	0		
	FEBRUARY	0	0	0	0		
	MARCH	1,448,872	1,159,098	8	27		
	APRIL	3,417,316	2,733,853	54	184		
	MAY	4,070,993	3,256,795	148	506		
	JUNE	17,084,400	13,667,520	305	1,040		
	JULY	17,084,400	13,667,520	360	1,228		
	AUGUST	17,084,400	13,667,520	363	1,238		
	SEPTEMBER	17,084,400	13,667,520	252	860		
	OCTOBER	4,559,566	3,647,653	78	266		
	NOVEMBER	810,021	648,016	1	3		
	DECEMBER	0	0	0	0		
TOTAL		17,084,400					
DESIGN		17,084,400					

# MONTHLY COOLING LOADS

06-Apr-92 ENERGY PLANT	MONTH	(A)		(B) = (A*0.8)		(C)		(D) = C*1000*3413/1,000,000	
		PEAK COOLING (BTU/H)	PEAK COOLING (BTU/H)	PEAK W/80% DIVERSITY (BTU/H)	COOLING CONSUMPT. (1000KWH)	COOLING CONSUMPT. (MMBTU)	COOLING CONSUMPT. (MMBTU)	COOLING CONSUMPT. (MMBTU)	COOLING CONSUMPT. (MMBTU)
4701	JANUARY	0	0	0	0	0	0	0	0
	FEBRUARY	0	0	0	0	0	0	0	0
	MARCH	476,441	476,441	381,152	0	0	0	0	0
	APRIL	1,060,900	1,060,900	848,720	5	16	16	16	16
	MAY	1,700,947	1,700,947	1,360,758	18	62	62	62	62
	JUNE	5,077,200	5,077,200	4,061,760	50	170	170	170	170
	JULY	5,077,200	5,077,200	4,061,760	65	221	221	221	221
	AUGUST	5,077,200	5,077,200	4,061,760	60	206	206	206	206
	SEPTEMBER	5,077,200	5,077,200	4,061,760	36	123	123	123	123
	OCTOBER	2,398,862	2,398,862	1,919,089	6	20	20	20	20
	NOVEMBER	0	0	0	0	0	0	0	0
	DECEMBER	0	0	0	0	0	0	0	0
	TOTAL	5,077,200	5,077,200						
5676	DESIGN	5,077,200	5,077,200						
	JANUARY	0	0	0	0	0	0	0	0
	FEBRUARY	0	0	0	0	0	0	0	0
	MARCH	154,451	154,451	123,561	1	3	3	3	3
	APRIL	364,290	364,290	291,432	7	24	24	24	24
	MAY	433,973	433,973	347,178	19	66	66	66	66
	JUNE	1,861,200	1,861,200	1,488,960	41	141	141	141	141
	JULY	1,861,200	1,861,200	1,488,960	49	168	168	168	168
	AUGUST	1,861,200	1,861,200	1,488,960	33	114	114	114	114
	SEPTEMBER	1,861,200	1,861,200	1,488,960	10	34	34	34	34
	OCTOBER	486,055	486,055	388,844	0	0	0	0	0
	NOVEMBER	86,349	86,349	69,079	0	0	0	0	0
	DECEMBER	0	0	0	0	0	0	0	0
	TOTAL	1,861,200	1,861,200						
	DESIGN	1,861,200	1,861,200						

# MONTHLY COOLING LOADS

06-Apr-92 (A) (B) = (A\*0.8) (C) (D) = C\*1000\*3413/1,000,000

ENERGY PLANT	MONTH	PEAK COOLING (BTU/H)	PEAK W/80% DIVERSITY (BTU/H)	COOLING CONSUMPT. (1000kWH)	COOLING CONSUMPT. (MMBTU)
5678	JANUARY	0	0	0	0
	FEBRUARY	0	0	0	0
	MARCH	178,004	142,403	1	4
	APRIL	419,841	335,873	8	27
	MAY	500,150	400,120	22	76
	JUNE	2,419,200	1,935,360	47	162
	JULY	2,419,200	1,935,360	57	193
	AUGUST	2,419,200	1,935,360	57	194
	SEPTEMBER	2,419,200	1,935,360	38	131
	OCTOBER	560,174	448,139	11	39
	NOVEMBER	99,517	79,613	0	0
	DECEMBER	0	0	0	0
	TOTAL	2,419,200	1,935,360	242	827
5900	DESIGN	2	2		
	JANUARY	0	0	0	0
	FEBRUARY	0	0	0	0
	MARCH	1,632,010	1,305,608	15	52
	APRIL	3,850,831	3,080,665	88	300
	MAY	6,514,764	5,211,811	2,159	7,368
	JUNE	22,980,000	18,384,000	8,879	30,305
	JULY	22,980,000	18,384,000	2,487	8,487
	AUGUST	22,980,000	18,384,000	2,489	8,494
	SEPTEMBER	22,980,000	18,384,000	2,311	7,888
	OCTOBER	5,138,309	4,110,647	121	412
	NOVEMBER	911,492	729,193	3	9
	DECEMBER	0	0	0	0
	TOTAL	22,980,000			
	DESIGN	22,980,000			

# MONTHLY COOLING LOADS

06-Apr-92 ENERGY PLANT	MONTH	(A)		(B) = (A*0.8)		(C)		(D) = C*1000*3413/1,000,000	
		PEAK COOLING (BTU/H)	PEAK W/80% DIVERSITY (BTU/H)	COOLING CONSUMPT. (1000kWH)	COOLING CONSUMPT. (MMBTU)				
6003	JANUARY	0	0	0	0			0	
	FEBRUARY	0	0	0	0			0	
	MARCH	836,554	669,243	5	19			19	
	APRIL	1,937,143	1,549,714	33	112			112	
	MAY	4,041,274	3,233,019	1,811	6,182			6,182	
	JUNE	10,656,000	8,524,800	1,908	6,504			6,504	
	JULY	10,656,000	8,524,800	1,941	6,625			6,625	
	AUGUST	10,656,000	8,524,800	1,941	6,626			6,626	
	SEPTEMBER	10,656,000	8,524,800	1,871	6,387			6,387	
	OCTOBER	2,521,534	2,017,227	45	155			155	
	NOVEMBER	439,220	351,376	1	3			3	
	DECEMBER	0	0	0	0			0	
	TOTAL	10,656,000							
	DESIGN	10,656,000							

**MONTHLY CENTRAL PLANT ENERGY CONSUMPTION  
AND  
ELECTRICAL DEMAND**

# BASELINE

12-Apr

BLDG NO.	RUN NO.	ENERGY USAGE	MONTH												TOTAL
			JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
730	RUN 1	GAS CONSM. (MCF)	6092	4450	2993										20988
		ELEC.DEMAND (KW)	525	525	525	525	525	525	525	525	525	525	525	525	6300
	RUN 2	ELEC.CONSM. (KWH)	31000	25000	23000		143000	140000	169000	158000	143000		23000	28000	883000
		GAS CONSM. (MCF)				224	235	205	235	224	224	235			1582
		ELEC.DEMAND (KW)	130	130	130	130	130	130	130	130	130	130	130	130	1560
914	RUN 1	ELEC.CONSM. (KWH)				43000	12000	10000	11000	11000	11000	46000			144000
		GAS CONSM. (MCF)	3121	3197	2213								1371	3435	13337
	RUN 2	ELEC.DEMAND (KW)	286	286	286	286	286	286	286	286	286	286	286	286	3432
		ELEC.CONSM. (KWH)					73000	117000	138000	137000	98000				563000
		GAS CONSM. (MCF)	44	39	44	42	44	42	44	44	42	44	42	44	515
2812	RUN 1	ELEC.DEMAND (KW)													
		ELEC.CONSM. (KWH)													
	RUN 2	GAS CONSM. (MCF)	7351	6124	4512								3330	6134	27451
		ELEC.DEMAND (KW)	192	192	192	192	192	192	192	192	192	192	192	192	2304
		ELEC.CONSM. (KWH)	11000	10000	11000	1030	1064	1030	1064	1064	1030	1064	11000	11000	480000
3442	RUN 1	ELEC.DEMAND (KW)	8	8	8	8	8	8	8	8	8	8	8	8	96
		ELEC.CONSM. (KWH)													
	RUN 2	GAS CONSM. (MCF)	284	263	291	5000	6000	5000	6000	6000	5000	6000	281	291	39000
		ELEC.DEMAND (KW)				282	291	280	291	291	282	291			3418
		ELEC.CONSM. (KWH)													
4701	RUN 1	ELEC.DEMAND (KW)	590	590	590	590	590	590	590	590	590	590	590	590	7080
		ELEC.CONSM. (KWH)					203000	274000	308000	308000	247000				1340000
	RUN 2	GAS CONSM. (MCF)	2164	1672	1166								997	1877	7876
		ELEC.DEMAND (KW)	396	396	396	396	396	396	396	396	396	396	396	396	4752
		ELEC.CONSM. (KWH)					61000	56000	66000	62000	61000				306000
5676	RUN 1	GAS CONSM. (MCF)				239	252	242	250	243	242	252			1720
		ELEC.DEMAND (KW)													
	RUN 2	ELEC.CONSM. (KWH)													
		GAS CONSM. (MCF)	4201	2927	1984								1296	3074	13462
		ELEC.DEMAND (KW)	165	165	165	165	165	165	165	165	165	165	165	165	1980
5678	RUN 1	ELEC.CONSM. (KWH)					35000	63000	75000	75000	51000				299000
		GAS CONSM. (MCF)	4226	3817	2976								1582	3729	16330
	RUN 2	ELEC.DEMAND (KW)	106	106	106	106	106	106	106	106	106	106	106	106	1272
		ELEC.CONSM. (KWH)					34000	48000	54000	55000	42000				233000
		GAS CONSM. (MCF)	49169	36204	27667								20512	38503	172255
5900	RUN 1	ELEC.DEMAND (KW)	1886	1886	1886	1886	192000	476000	595000	598000	363000		1886	1886	22632
		ELEC.CONSM. (KWH)													2224000
	RUN 2	GAS CONSM. (MCF)	20309	15009	11800								8592	15913	71623
		ELEC.DEMAND (KW)	417	417	417	417	155000	199000	221000	221000	181000		417	417	5004
		ELEC.CONSM. (KWH)													977000
6003	RUN 1	ELEC.DEMAND (KW)				2997	3098	2997	3098	3098	2997	3098			21393
		ELEC.CONSM. (KWH)													
	RUN 2	GAS CONSM. (MCF)													
		ELEC.DEMAND (KW)													
		ELEC.CONSM. (KWH)													

**HISTORICAL WEATHER DATA AT FT. SILL**

**HISTORICAL DATA  
OF  
HEATING AND COOLING PERIOD  
AT FT. SILL, OKLAHOMA**

[H-C-DAYS.WK3]

Year	Cooling		Cooling Day	Heating		Heating Day	Spring Day	Fall Day
	From	To		From	To			
1981	30-May-81	15-Oct-81	135	04-Oct-81	21-Apr-82	197		46
1982	07-Jun-82	22-Sep-82	105	23-Oct-82	12-Apr-83	169	31	61
1983	13-Jun-83	20-Sep-83	97	22-Oct-83	24-Apr-84	182	32	44
1984	08-Jun-84	24-Sep-84	106	25-Oct-84	19-Apr-85	174	31	40
1985	29-May-85	26-Sep-85	117	04-Oct-85	05-Apr-86	181	8	63
1986	08-Jun-86	06-Oct-86	118	14-Oct-86	08-Apr-87	174	8	41
1987	19-May-87	29-Sep-87	130	12-Nov-87	24-Apr-88	162	43	14
1988	08-May-88	29-Sep-88	141	12-Nov-88	11-Apr-89	149	43	
<b>AVG. NUMBER OF DAYS</b>			119			174	28	44

THESE INFORMATION WERE GIVEN TO EMC BY FT. SILL. THIS INDICATES WHEN HEATING AND COOLING BEGIN AND END. THE AVERAGE NUMBER OF DAYS ARE USED IN THE PC-CUBE PROGRAM TO CALCULATE ENERGY CONSUMPTION.

THE DESIGN COOLING AND HEATING SET POINTS ARE:

101 DEGREE F (DB) FOR COOLING

12 DEGREE F (DB) FOR HEATING

BASE ON THE AVERAGE TEMPERATURE AT FT. SILL, THE PEAK HEATING AND COOLING OCCUR ON THE FOLLOWING MONTHS

MONTH	HTG	CLG
MAY		
JUN		
JUL		
AUG		
SEP		
OCT		
NOV		
DEC		
JAN		
FEB		
MAR		
APR		



MONTHS WHERE PEAK HEATING/COOLING REQUIRED

# AVERAGE TEMP CALC. @ FT. SILL

	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
107								0	2	3		
102					0		0	4	26	22	2	
97					0	0	3	27	78	58	12	
92					1	3	14	67	103	90	37	6
87					4	13	45	100	110	104	62	17
82	2	0	0	1	9	30	79	122	139	128	87	40
77	14	1	0	3	17	55	105	140	154	156	121	50
72	32	4	5	7	31	84	139	132	100	133	140	91
67	48	13	11	17	48	118	140	84	26	40	120	111
62	73	32	25	32	66	126	117	35	4	9	77	127
57	85	56	37	49	81	110	62	9	1	2	40	118
52	112	77	53	66	97	86	29	1			17	86
47	111	107	79	88	103	51	11				3	62
42	108	113	104	109	106	27	2				0	28
37	78	125	112	104	87	13	0					7
32	36	107	112	86	56	5						1
27	13	62	85	62	23	1						1
22	5	32	53	33	8	0						
17	0	9	37	10	4							
12	0	6	16	2	1							
7	0	1	11									
2												

	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
107	0	0	0	0	0	0	0	0	214	321	0	0
102	0	0	0	0	0	0	0	408	2652	2244	204	0
97	0	0	0	0	0	0	291	2619	7566	5626	1164	0
92	0	0	0	0	92	276	1288	6164	9476	8280	3404	552
87	0	0	0	0	348	1131	3915	8700	9570	9048	5394	1479
82	164	0	0	82	738	2460	6478	10004	11398	10496	7134	3280
77	1078	77	0	231	1309	4235	8085	10780	11858	12012	9317	3850
72	2304	288	360	504	2232	6048	10008	9504	7200	9576	10080	6552
67	3216	871	737	1139	3216	7906	9380	5628	1742	2680	8040	7437
62	4526	1984	1550	1984	4092	7812	7254	2170	248	558	4774	7874
57	4845	3192	2109	2793	4617	6270	3534	513	57	114	2280	6726
52	5824	4004	2756	3432	5044	4472	1508	52	0	0	884	4472
47	5217	5029	3713	4136	4841	2397	517	0	0	0	141	2914
42	4536	4746	4368	4578	4452	1134	84	0	0	0	0	1176
37	2886	4625	4144	3848	3219	481	0	0	0	0	0	259
32	1152	3424	3584	2752	1792	160	0	0	0	0	0	32
27	351	1674	2295	1674	621	27	0	0	0	0	0	27
22	110	704	1166	726	176	0	0	0	0	0	0	0
17	0	153	629	170	68	0	0	0	0	0	0	0
12	0	72	192	24	12	0	0	0	0	0	0	0
7	0	7	77	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
AVG	51	41	37	42	50	62	70	78	83	82	74	63
	58	58	58	58	58	58	58	58	58	58	58	58

STATE	Station	LOCATION		WINTER DESIGN DATA HEATING				DEGREE DAYS	SUMMER DESIGN DATA AIR CONDITIONING										SUMMER CRITERIA DATA AIR CONDITIONING			
				Dry Bulb					Dry Bulb				Wet Bulb		Wet Bulb		Dry Bulb		Wet Bulb			
		Lat	Long	Elev	feet	99%	97.5%	Wind Speed	Dir	knots	annual	Heating	1% MCWB	2.5% MCWB	Range	Mean Daily Wind	5% MCWB	1% MCWB	2.5% 5%	hrs	hrs	hrs	hrs
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°		
OHIO (CONT)	N 41 21	82 11	W	794	1	6	SW	8	SW	8	6094	93 73	91 72	24	SW	88 71	76 74	73	38	681	176	997
	40 49	82 31		1295	0	5	W	8	W	8	5818	90 73	87 72	21	SW	85 72	76 74	73	9	431	183	989
	40 01	82 28		880	-1	5	W	8	W	8	5655	94 73	92 73	24	SSW	89 72	77 75	74	56	745	282	1301
	38 45	82 55		540	-5	10	W	8	W	8	4547	95 76	92 74	22	SW	89 73	78 77	75	66	942	470	1671
	41 11	81 06		1130	-2	4	SW	9	SW	9	6262	93 73	90 72	22	SW	87 71	76 74	73	38	563	176	1054
	39 49	82 56		744	-1	3	W	8	W	8	5567	90 74	88 73	22	WSW	86 72	77 75	73	11	575	223	1147
	39 15	84 40		670	-1	6	W	9	W	9	5070	92 73	90 72	23	SW	88 72	77 75	74	24	748	316	1423
	39 50	83 50		1052	-1	3	W	7	W	7	5284	91 74	89 73	22	W	87 72	77 76	74	12	686	297	1293
	41 36	83 48		669	-3	1	WSW	8	WSW	8	6381	90 73	88 73	25	SW	85 71	76 75	73	11	506	197	997
	39 49	84 03		824	-1	3	W	7	W	7	5455	91 74	89 73	22	SW	87 72	77 76	74	12	686	297	1293
	41 16	80 40		1178	-1	4	SW	10	SW	10	6426	88 71	86 71	23	SW	84 70	74 73	71	4	371	82	729
	39 57	81 54		900	-1	7	W	6	W	6	5738	93 75	90 74	27	WSW	87 73	78 76	75	28	627	339	1314
OKLAHOMA	N 34 39	99 16	W	1378	11	16	N	10	N	10	3346	102 73	100 73	26	S	98 73	77 76	75	422	1684	633	2292
	35 20	99 12		1928	6	12	N	12	N	12	3931	100 73	97 72	25	S	95 71	75 74	74	243	1339	283	1821
	34 39	98 24		1187	12	16	N	12	N	12	3367	101 74	99 74	25	S	96 74	78 77	76	346	1601	797	2412
	34 50	95 55		776	14	19	N	10	N	10	3255	99 74	96 74	24	S	93 74	77 76	75	181	1505	618	2211
	35 15	97 29		1181	9	13	N	10	N	10	3247	99 74	96 74	22	S	94 74	77 76	75	193	1331	618	2211
	35 24	97 22		1262	9	13	N	10	N	10	3588	99 74	96 74	22	S	94 74	77 76	75	193	1331	618	2211
	35 24	97 36		1285	9	13	N	14	N	14	3695	100 74	97 74	24	SSW	95 73	78 77	76	240	1392	799	2357
	36 10	97 05		984	8	13	N	12	N	12	3631	100 74	96 74	25	SSW	93 74	77 76	75	145	1410	618	2211
	35 25	97 23		1291	9	13	N	10	N	10	3588	99 74	96 74	22	S	94 74	77 76	75	193	1331	618	2211
	36 12	95 54		650	8	13	N	11	N	11	3680	101 74	98 75	24	SSW	95 75	79 78	77	270	1543	1089	2478
	36 21	97 55		1307	9	13	NNE	13	NNE	13	3971	103 74	100 74	26	SSW	97 74	79 77	76	373	1521	836	2234
	OREGON	N 46 09	123 53	W	8	25	29	ESE	7	ESE	7	5295	75 65	71 62	20	NNW	68 61	65 63	62	1	16	0	14
43 35		119 03		4151	0	6	WNW	6	WNW	6	7212	91 61	89 59	35	NNW	86 58	63 61	60	19	462	0	1
44 30		123 17		246	18	22	N	6	N	6	4854	92 67	89 66	33	N	86 65	69 67	66	27	372	4	100
44 07		123 13		359	17	22	N	7	N	7	4739	92 67	89 66	33	N	86 65	69 67	66	28	393	4	100
42 26		123 19		925	20	24	N	5	N	5	4375	99 69	96 68	38	N	93 67	71 69	68	160	700	9	255
42 04		121 58		6400	-3	2	N	7	N	7	7687	83 57	80 56	28	W	77 55	59 57	56	0	70	0	0
42 09		121 44		4092	4	9	N	4	N	4	6987	90 61	87 60	37	W	84 59	63 61	60	6	354	0	1
42 09		121 44		4092	4	9	N	4	N	4	6987	90 61	87 60	37	W	84 59	63 61	60	6	354	0	1

FORT SILL/POST AAF OKLAHOMA

Temperature Range	NOVEMBER				DECEMBER				JANUARY				FEBRUARY				MARCH				APRIL				ANNUAL TOTAL			
	Obsn		Hour Gp		Obsn		Hour Gp		Obsn		Hour Gp		Obsn		Hour Gp		Obsn		Hour Gp		Obsn		Hour Gp		Obsn		Hour Gp	
	01	09	17	24	01	09	17	24	01	09	17	24	01	09	17	24	01	09	17	24	01	09	17	24	01	09	17	24
105/109																												
100/104																												
95/99																												
90/94																												
85/89																												
80/84																												
75/79																												
70/74																												
65/69																												
60/64																												
55/59																												
50/54																												
45/49																												
40/44																												
35/39																												
30/34																												
25/29																												
20/24																												
15/19																												
10/14																												
5/9																												
0/4																												
-5/-1																												

FORT SILL/POST AAF OKLAHOMA

LAT 34 39N LONG 98 24W ELEV 1187 FT

MEAN FREQUENCY OF OCCURRENCE OF DRY BULB TEMPERATURE (DEGREES F) WITH MEAN COINCIDENT WET BULB TEMPERATURE (DEGREES F) FOR EACH DRY BULB TEMPERATURE RANGE

Tempera- ture Range	MAY				JUNE				JULY				AUGUST				SEPTEMBER				OCTOBER			
	Obsn		Total		Obsn		Total		Obsn		Total		Obsn		Total		Obsn		Total		Obsn		Total	
	Hour Cp		Hour Cp		Hour Cp		Hour Cp		Hour Cp		Hour Cp		Hour Cp		Hour Cp		Hour Cp		Hour Cp		Hour Cp		Hour Cp	
	01	05	09	13	17	21	01	05	09	13	17	21	01	05	09	13	17	21	01	05	09	13	17	21
105/109							0	0	76				2	0	2	74								
100/104							3	1	4				16	6	22	74								
95/99							16	9	27	74			38	20	58	74								
90/94							42	25	67	74			55	35	90	73								
85/89							1	57	42	100	72		2	53	49	104	72							
80/84							15	51	56	122	71		27	43	58	128	71							
75/79							55	33	52	140	69		81	25	50	156	69							
70/74							80	21	31	132	67		97	12	24	133	67							
65/69							57	11	16	84	64		32	3	5	40	63							
60/64							24	4	7	35	60		7	1	1	9	58							
55/59							7	1	1	9	55		2	0	0	2	55							
50/54							1																	
45/49																								
40/44																								
35/39																								
30/34																								
25/29																								

FORT SILL/POST AAF OKLAHOMA

TEMP BIN	TIME GROUP						TOTAL	HORIZ. SOLAR (BTUH/SQ.FT.)
	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24		

## DRY-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCWB)

90 / 94	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 71 )	1 ( 71 )	0 ( 0 )	3 ( 71 )	123
85 / 89	0 ( 0 )	0 ( 0 )	0 ( 0 )	16 ( 70 )	4 ( 70 )	0 ( 0 )	20 ( 70 )	196
80 / 84	0 ( 0 )	0 ( 0 )	7 ( 69 )	15 ( 63 )	11 ( 67 )	0 ( 0 )	33 ( 66 )	199
75 / 79	0 ( 0 )	0 ( 0 )	14 ( 65 )	17 ( 63 )	20 ( 66 )	8 ( 68 )	59 ( 65 )	142
70 / 74	19 ( 66 )	12 ( 66 )	20 ( 63 )	13 ( 59 )	18 ( 62 )	26 ( 66 )	108 ( 64 )	134
65 / 69	11 ( 63 )	18 ( 64 )	11 ( 56 )	9 ( 51 )	9 ( 53 )	11 ( 58 )	69 ( 59 )	142
60 / 64	15 ( 56 )	7 ( 59 )	14 ( 49 )	21 ( 47 )	15 ( 48 )	11 ( 53 )	83 ( 51 )	140
55 / 59	11 ( 50 )	6 ( 51 )	17 ( 46 )	9 ( 45 )	18 ( 46 )	7 ( 48 )	68 ( 47 )	168
50 / 54	14 ( 44 )	22 ( 46 )	10 ( 42 )	9 ( 43 )	9 ( 43 )	21 ( 45 )	85 ( 44 )	130
45 / 49	14 ( 41 )	13 ( 42 )	17 ( 42 )	9 ( 41 )	13 ( 41 )	15 ( 41 )	81 ( 41 )	103
40 / 44	19 ( 37 )	23 ( 38 )	10 ( 38 )	0 ( 0 )	2 ( 39 )	16 ( 39 )	70 ( 38 )	73
35 / 39	14 ( 35 )	16 ( 35 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	5 ( 36 )	35 ( 35 )	39
30 / 34	3 ( 32 )	3 ( 32 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	6 ( 32 )	44

## WET-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCDB)

72 / 73	0 ( 0 )	0 ( 0 )	0 ( 0 )	3 ( 86 )	1 ( 85 )	0 ( 0 )	4 ( 86 )
70 / 71	0 ( 0 )	0 ( 0 )	4 ( 81 )	12 ( 87 )	7 ( 82 )	0 ( 0 )	23 ( 84 )
68 / 69	0 ( 0 )	1 ( 74 )	7 ( 79 )	13 ( 81 )	13 ( 80 )	7 ( 75 )	41 ( 79 )
66 / 67	13 ( 71 )	11 ( 70 )	13 ( 75 )	5 ( 76 )	13 ( 75 )	19 ( 73 )	74 ( 73 )
64 / 65	14 ( 69 )	11 ( 69 )	9 ( 72 )	3 ( 75 )	2 ( 74 )	9 ( 71 )	48 ( 71 )
62 / 63	2 ( 67 )	7 ( 67 )	3 ( 70 )	8 ( 80 )	5 ( 79 )	0 ( 0 )	25 ( 74 )
60 / 61	3 ( 63 )	3 ( 65 )	1 ( 76 )	1 ( 72 )	3 ( 72 )	1 ( 70 )	12 ( 68 )
58 / 59	3 ( 63 )	3 ( 64 )	2 ( 70 )	6 ( 74 )	5 ( 75 )	6 ( 65 )	25 ( 69 )
56 / 57	5 ( 64 )	0 ( 0 )	6 ( 69 )	5 ( 77 )	1 ( 66 )	4 ( 63 )	21 ( 68 )
54 / 55	4 ( 60 )	2 ( 56 )	4 ( 67 )	7 ( 75 )	7 ( 71 )	4 ( 63 )	28 ( 67 )
52 / 53	1 ( 59 )	0 ( 0 )	8 ( 67 )	4 ( 67 )	8 ( 64 )	3 ( 64 )	24 ( 65 )
50 / 51	5 ( 57 )	4 ( 57 )	4 ( 61 )	11 ( 61 )	6 ( 58 )	3 ( 61 )	33 ( 59 )
48 / 49	5 ( 58 )	5 ( 53 )	8 ( 58 )	7 ( 58 )	10 ( 60 )	4 ( 58 )	39 ( 58 )
46 / 47	6 ( 52 )	7 ( 53 )	9 ( 53 )	7 ( 62 )	9 ( 56 )	5 ( 53 )	43 ( 55 )
44 / 45	4 ( 51 )	12 ( 52 )	8 ( 56 )	13 ( 59 )	11 ( 57 )	15 ( 52 )	63 ( 55 )
42 / 43	7 ( 47 )	8 ( 48 )	9 ( 53 )	5 ( 52 )	7 ( 50 )	11 ( 50 )	47 ( 50 )
40 / 41	11 ( 47 )	7 ( 45 )	11 ( 48 )	2 ( 47 )	3 ( 46 )	11 ( 46 )	45 ( 47 )
38 / 39	13 ( 42 )	7 ( 42 )	8 ( 46 )	8 ( 51 )	8 ( 48 )	7 ( 43 )	51 ( 45 )
36 / 37	11 ( 39 )	18 ( 40 )	6 ( 43 )	0 ( 0 )	1 ( 47 )	7 ( 41 )	43 ( 41 )
34 / 35	8 ( 38 )	8 ( 37 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	4 ( 38 )	20 ( 38 )
32 / 33	4 ( 36 )	6 ( 35 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	10 ( 35 )

## AVERAGE VALUES:

DRY-BULB AVERAGES	53.5	52.3	61.6	69.4	65.8	58	60.1	DEG.F
WET-BULB AVERAGES	48.6	47.8	52.2	55.6	54.6	51.4	51.7	DEG.F
DAILY HORIZONTAL SOLAR		120	727	751	132		1730	BTU/SQ.FT.
WIND SPEED AVERAGES	14.9	16.3	18.1	17.7	15.6	14.3	16.1	MPH

TEMP BIN	TIME GROUP						TOTAL	HORIZ. SOLAR (BTUH/SQ.FT.)
	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24		

## DRY-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCWB)

90 / 94	0 ( 0 )	0 ( 0 )	0 ( 0 )	4 ( 68 )	1 ( 64 )	0 ( 0 )	5 ( 67 )	196
85 / 89	0 ( 0 )	0 ( 0 )	2 ( 72 )	18 ( 70 )	6 ( 70 )	0 ( 0 )	26 ( 70 )	209
80 / 84	0 ( 0 )	0 ( 0 )	17 ( 68 )	40 ( 68 )	28 ( 68 )	0 ( 0 )	85 ( 68 )	157
75 / 79	1 ( 70 )	3 ( 71 )	27 ( 66 )	25 ( 63 )	34 ( 66 )	12 ( 67 )	102 ( 66 )	150
70 / 74	15 ( 64 )	14 ( 65 )	30 ( 62 )	14 ( 60 )	26 ( 63 )	27 ( 64 )	126 ( 63 )	154
65 / 69	37 ( 62 )	29 ( 62 )	20 ( 57 )	12 ( 54 )	14 ( 55 )	35 ( 62 )	147 ( 60 )	133
60 / 64	34 ( 58 )	28 ( 56 )	17 ( 54 )	8 ( 54 )	7 ( 53 )	24 ( 57 )	118 ( 56 )	106
55 / 59	16 ( 53 )	35 ( 53 )	9 ( 53 )	3 ( 56 )	7 ( 52 )	18 ( 52 )	88 ( 53 )	60
50 / 54	12 ( 48 )	7 ( 47 )	2 ( 43 )	0 ( 0 )	1 ( 46 )	5 ( 47 )	27 ( 47 )	96
45 / 49	5 ( 45 )	5 ( 43 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	3 ( 44 )	13 ( 44 )	56
40 / 44	4 ( 40 )	2 ( 40 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	6 ( 40 )	0
35 / 39	0 ( 0 )	1 ( 37 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 37 )	8

## WET-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCDB)

74 / 75	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 87 )	0 ( 0 )	0 ( 0 )	1 ( 87 )
72 / 73	0 ( 0 )	0 ( 0 )	5 ( 81 )	21 ( 84 )	7 ( 85 )	0 ( 0 )	33 ( 84 )
70 / 71	2 ( 74 )	4 ( 75 )	7 ( 80 )	6 ( 82 )	15 ( 80 )	0 ( 0 )	34 ( 79 )
68 / 69	2 ( 73 )	1 ( 72 )	16 ( 79 )	22 ( 81 )	21 ( 78 )	12 ( 75 )	74 ( 78 )
66 / 67	2 ( 71 )	4 ( 70 )	15 ( 75 )	10 ( 81 )	17 ( 77 )	7 ( 72 )	55 ( 76 )
64 / 65	8 ( 69 )	11 ( 69 )	13 ( 73 )	10 ( 81 )	8 ( 78 )	19 ( 71 )	69 ( 73 )
62 / 63	27 ( 66 )	19 ( 67 )	7 ( 75 )	13 ( 79 )	12 ( 78 )	20 ( 68 )	98 ( 71 )
60 / 61	16 ( 65 )	9 ( 65 )	9 ( 73 )	4 ( 79 )	6 ( 73 )	18 ( 67 )	62 ( 69 )
58 / 59	11 ( 62 )	11 ( 63 )	10 ( 70 )	5 ( 65 )	2 ( 73 )	8 ( 66 )	47 ( 65 )
56 / 57	14 ( 62 )	14 ( 60 )	15 ( 62 )	10 ( 70 )	10 ( 70 )	3 ( 64 )	66 ( 64 )
54 / 55	8 ( 60 )	15 ( 59 )	7 ( 64 )	13 ( 69 )	12 ( 64 )	11 ( 59 )	66 ( 63 )
52 / 53	8 ( 60 )	7 ( 58 )	8 ( 66 )	6 ( 66 )	8 ( 66 )	8 ( 58 )	45 ( 62 )
50 / 51	5 ( 54 )	6 ( 57 )	8 ( 63 )	2 ( 64 )	2 ( 60 )	4 ( 59 )	27 ( 59 )
48 / 49	6 ( 54 )	11 ( 57 )	1 ( 58 )	1 ( 60 )	2 ( 60 )	8 ( 56 )	29 ( 56 )
46 / 47	7 ( 51 )	3 ( 52 )	1 ( 57 )	0 ( 0 )	2 ( 54 )	2 ( 52 )	15 ( 52 )
44 / 45	3 ( 48 )	3 ( 48 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 49 )	8 ( 48 )
42 / 43	1 ( 45 )	2 ( 47 )	2 ( 52 )	0 ( 0 )	0 ( 0 )	2 ( 46 )	7 ( 48 )
40 / 41	3 ( 43 )	2 ( 45 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	5 ( 43 )
38 / 39	1 ( 40 )	1 ( 40 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 40 )
36 / 37	0 ( 0 )	1 ( 39 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 39 )

## AVERAGE VALUES:

DRY-BULB AVERAGES	61.6	61.5	71.1	77.5	74.3	65.4	68.6	DEG.F
WET-BULB AVERAGES	57.1	56.6	61.2	63.9	63	59.4	60.2	DEG.F
DAILY HORIZONTAL SOLAR		172	770	814	174		1930	BTU/SQ.FT.
WIND SPEED AVERAGES	13.8	14.3	16.1	16.9	15.4	13.5	15	MPH

## WIND FREQUENCIES:

## HOURS OF OCCURRENCE (PREVAILING DIRECTION)

< 5.5 MPH	0 ( * )	3 ( ENE )	3 ( S )	4 ( E )	2 ( SSW )	0 ( * )	12 ( S )
5.5-14.4 MPH	78 ( SSE )	55 ( SSE )	40 ( SSE )	36 ( SSE )	51 ( SSE )	80 ( SE )	340 ( SSE )

TEMP BIN	TIME GROUP						HORIZ. SOLAR	
	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24	TOTAL	(BTUH/SQ.FT.)
DRY-BULB TEMPERATURES:								
HOURS OF OCCURRENCE (MCWB)								
95 / 99	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 77 )	0 ( 0 )	0 ( 0 )	2 ( 77 )	219
90 / 94	0 ( 0 )	0 ( 0 )	6 ( 76 )	40 ( 75 )	16 ( 75 )	0 ( 0 )	62 ( 75 )	209
85 / 89	0 ( 0 )	0 ( 0 )	30 ( 74 )	34 ( 74 )	32 ( 73 )	4 ( 74 )	100 ( 74 )	201
80 / 84	6 ( 72 )	5 ( 72 )	32 ( 73 )	14 ( 68 )	31 ( 72 )	15 ( 71 )	103 ( 72 )	175
75 / 79	19 ( 70 )	20 ( 71 )	21 ( 69 )	10 ( 67 )	15 ( 68 )	40 ( 71 )	125 ( 70 )	152
70 / 74	55 ( 69 )	45 ( 69 )	11 ( 65 )	9 ( 65 )	13 ( 67 )	33 ( 69 )	166 ( 68 )	101
65 / 69	20 ( 66 )	29 ( 65 )	13 ( 63 )	7 ( 65 )	9 ( 64 )	18 ( 64 )	96 ( 65 )	74
60 / 64	10 ( 59 )	12 ( 61 )	3 ( 60 )	2 ( 53 )	4 ( 56 )	8 ( 59 )	39 ( 59 )	62
55 / 59	8 ( 56 )	6 ( 55 )	3 ( 55 )	2 ( 53 )	0 ( 0 )	2 ( 53 )	21 ( 55 )	63
50 / 54	2 ( 51 )	3 ( 50 )	1 ( 52 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	6 ( 51 )	47

WET-BULB TEMPERATURES:								
HOURS OF OCCURRENCE (MCDB)								
78 / 79	0 ( 0 )	0 ( 0 )	3 ( 91 )	4 ( 94 )	4 ( 93 )	0 ( 0 )	11 ( 93 )	
76 / 77	0 ( 0 )	0 ( 0 )	1 ( 86 )	12 ( 93 )	6 ( 91 )	0 ( 0 )	19 ( 92 )	
74 / 75	0 ( 0 )	1 ( 82 )	26 ( 86 )	34 ( 88 )	26 ( 87 )	4 ( 85 )	91 ( 87 )	
72 / 73	13 ( 77 )	8 ( 78 )	41 ( 84 )	28 ( 88 )	27 ( 84 )	28 ( 78 )	145 ( 83 )	
70 / 71	32 ( 74 )	32 ( 74 )	12 ( 78 )	9 ( 81 )	20 ( 81 )	28 ( 76 )	133 ( 76 )	
68 / 69	26 ( 71 )	23 ( 72 )	7 ( 70 )	6 ( 76 )	11 ( 79 )	21 ( 73 )	94 ( 73 )	
66 / 67	20 ( 71 )	22 ( 69 )	4 ( 73 )	9 ( 76 )	10 ( 73 )	15 ( 71 )	80 ( 72 )	
64 / 65	5 ( 67 )	8 ( 67 )	5 ( 71 )	4 ( 71 )	2 ( 68 )	4 ( 72 )	28 ( 69 )	
62 / 63	4 ( 65 )	8 ( 64 )	9 ( 68 )	6 ( 75 )	6 ( 72 )	8 ( 66 )	41 ( 68 )	
60 / 61	4 ( 62 )	6 ( 63 )	4 ( 75 )	3 ( 73 )	4 ( 72 )	3 ( 63 )	24 ( 68 )	
58 / 59	6 ( 61 )	3 ( 62 )	1 ( 58 )	1 ( 71 )	0 ( 0 )	4 ( 65 )	15 ( 62 )	
56 / 57	4 ( 59 )	3 ( 58 )	2 ( 69 )	0 ( 0 )	2 ( 64 )	1 ( 64 )	12 ( 62 )	
54 / 55	3 ( 58 )	3 ( 58 )	3 ( 62 )	0 ( 0 )	2 ( 63 )	2 ( 62 )	13 ( 60 )	
52 / 53	1 ( 55 )	0 ( 0 )	2 ( 55 )	4 ( 59 )	0 ( 0 )	2 ( 58 )	9 ( 57 )	
50 / 51	2 ( 53 )	2 ( 53 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	4 ( 53 )	
48 / 49	0 ( 0 )	1 ( 50 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 50 )	

AVERAGE VALUES:								
DRY-BULB AVERAGES	70.1	69.8	79.1	84.1	81.5	73.6	76.4	DEG.F
WET-BULB AVERAGES	66.8	66.6	69.9	71	70.5	68.2	68.8	DEG.F
DAILY HORIZONTAL SOLAR		197	868	869	216		2149	BTU/SQ.FT.
WIND SPEED AVERAGES	11.3	12.2	15.7	15.4	14	12.2	13.5	MPH

WIND FREQUENCIES:								
HOURS OF OCCURRENCE (PREVAILING DIRECTION)								
< 5.5 MPH	15 (S)	9 (NNW)	2 (NNE)	5 (NNW)	3 (NE)	4 (NE)	38 (N)	
5.5-14.4 MPH	77 (SSE)	72 (SSE)	51 (SSW)	44 (SSE)	59 (SSE)	82 (SSE)	385 (SSE)	
14.5-21.0 MPH	27 (SSE)	33 (S)	46 (SSW)	53 (S)	53 (SSE)	34 (SSE)	246 (SSE)	
>21.0 MPH	1 (NNW)	6 (S)	21 (S)	18 (S)	5 (SSE)	0 (*)	51 (S)	

DEGREE HOURS (HEATING/COOLING)							
TIME GROUP							
TEMP BASE	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24	TOTAL

TEMP BIN	TIME GROUP						TOTAL	HORIZ. SOLAR (BTU/SQ.FT.)
	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24		

## DRY-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCWB)

100 / 104

100 / 104	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 77 )	0 ( 0 )	0 ( 0 )	2 ( 77 )	208
95 / 99	0 ( 0 )	0 ( 0 )	2 ( 76 )	42 ( 77 )	21 ( 76 )	0 ( 0 )	65 ( 77 )	203
90 / 94	0 ( 0 )	0 ( 0 )	32 ( 76 )	35 ( 77 )	31 ( 76 )	0 ( 0 )	98 ( 76 )	196
85 / 89	2 ( 73 )	0 ( 0 )	38 ( 75 )	23 ( 75 )	26 ( 75 )	15 ( 74 )	104 ( 75 )	201
80 / 84	10 ( 72 )	23 ( 73 )	29 ( 74 )	16 ( 74 )	32 ( 74 )	39 ( 73 )	149 ( 74 )	131
75 / 79	53 ( 72 )	40 ( 72 )	14 ( 72 )	6 ( 74 )	11 ( 73 )	40 ( 73 )	164 ( 72 )	83
70 / 74	50 ( 71 )	51 ( 70 )	9 ( 71 )	0 ( 0 )	3 ( 72 )	28 ( 71 )	141 ( 70 )	38
65 / 69	9 ( 67 )	10 ( 67 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 68 )	21 ( 67 )	23

## WET-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCDB)

80 / 81	0 ( 0 )	0 ( 0 )	0 ( 0 )	3 ( 90 )	0 ( 0 )	0 ( 0 )	3 ( 90 )
78 / 79	0 ( 0 )	0 ( 0 )	6 ( 91 )	19 ( 94 )	6 ( 94 )	1 ( 87 )	32 ( 93 )
76 / 77	0 ( 0 )	1 ( 81 )	37 ( 89 )	55 ( 94 )	45 ( 90 )	8 ( 83 )	146 ( 91 )
74 / 75	11 ( 78 )	12 ( 80 )	44 ( 86 )	34 ( 87 )	48 ( 88 )	31 ( 81 )	180 ( 85 )
72 / 73	35 ( 76 )	39 ( 78 )	27 ( 79 )	13 ( 83 )	21 ( 82 )	52 ( 78 )	187 ( 79 )
70 / 71	46 ( 75 )	43 ( 74 )	9 ( 76 )	0 ( 0 )	3 ( 80 )	23 ( 77 )	124 ( 75 )
68 / 69	24 ( 73 )	20 ( 72 )	1 ( 74 )	0 ( 0 )	1 ( 76 )	8 ( 72 )	54 ( 73 )
66 / 67	8 ( 68 )	8 ( 69 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 69 )	17 ( 69 )
64 / 65	0 ( 0 )	1 ( 66 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 66 )

## AVERAGE VALUES:

DRY-BULB AVERAGES	74.9	75.1	84.8	90.9	87.5	78.6	82	DEG.F
WET-BULB AVERAGES	70.8	70.9	74.5	76	74.9	72.6	73.3	DEG.F
DAILY HORIZONTAL SOLAR		185	870	882	185		2124	BTU/SQ.FT.
WIND SPEED AVERAGES	9.600001	10.3	13.6	13.2	11.9	10.9	11.6	MPH

## WIND FREQUENCIES:

## HOURS OF OCCURRENCE (PREVAILING DIRECTION)

< 5.5 MPH	10 (S)	11 (N)	3 (ESE)	5 (NE)	5 (SW)	3 (SSE)	37 (N)
5.5-14.4 MPH	106 (S)	94 (S)	74 (SSW)	64 (SSE)	81 (S)	102 (SSE)	521 (SSE)
14.5-21.0 MPH	7 (SSE)	16 (SSW)	40 (SSW)	52 (SSW)	38 (S)	19 (SSE)	172 (SSW)
>21.0 MPH	1 (N)	3 (SSW)	7 (SSW)	3 (SSW)	0 (*)	0 (*)	14 (SSW)

## DEGREE HOURS (HEATING/COOLING)

## TIME GROUP

TEMP BASE	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24	TOTAL
75	189 / 179	203 / 221	19 / 1231	0 / 1977	3 / 1553	64 / 516	478 / 5677
70	17 / 627	20 / 658	0 / 1832	0 / 2597	0 / 2170	2 / 1074	39 / 8958
65	0 / 1230	0 / 1258	0 / 2452	0 / 3217	0 / 2790	0 / 1692	0 / 12639
60	0 / 1850	0 / 1878	0 / 3072	0 / 3837	0 / 3410	0 / 2312	0 / 16359
57	0 / 2222	0 / 2250	0 / 3444	0 / 4209	0 / 3782	0 / 2684	0 / 18591
55	0 / 2470	0 / 2498	0 / 3692	0 / 4457	0 / 4030	0 / 2932	0 / 20079
50	0 / 3090	0 / 3118	0 / 4312	0 / 5077	0 / 4650	0 / 3552	0 / 23799
45	0 / 3710	0 / 3738	0 / 4932	0 / 5697	0 / 5270	0 / 4172	0 / 27519
40	0 / 4330	0 / 4358	0 / 5552	0 / 6317	0 / 5890	0 / 4792	0 / 31239

TEMP BIN	TIME GROUP						HORIZ. SOLAR	
	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24	TOTAL	(BTUH/SQ.FT.)

## DRY-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCWB)

95 / 99	0 ( 0 )	0 ( 0 )	3 ( 73 )	25 ( 74 )	8 ( 74 )	0 ( 0 )	36 ( 74 )	178
90 / 94	0 ( 0 )	0 ( 0 )	16 ( 74 )	54 ( 73 )	32 ( 73 )	0 ( 0 )	102 ( 73 )	179
85 / 89	0 ( 0 )	0 ( 0 )	35 ( 72 )	24 ( 70 )	37 ( 71 )	5 ( 74 )	101 ( 71 )	195
80 / 84	4 ( 73 )	5 ( 72 )	37 ( 71 )	13 ( 70 )	30 ( 70 )	37 ( 71 )	126 ( 71 )	187
75 / 79	40 ( 70 )	21 ( 70 )	19 ( 69 )	6 ( 71 )	12 ( 69 )	41 ( 69 )	139 ( 69 )	137
70 / 74	45 ( 67 )	61 ( 68 )	13 ( 69 )	2 ( 70 )	5 ( 68 )	29 ( 66 )	155 ( 67 )	76
65 / 69	30 ( 63 )	25 ( 64 )	1 ( 68 )	0 ( 0 )	0 ( 0 )	12 ( 64 )	68 ( 64 )	53
60 / 64	5 ( 61 )	12 ( 61 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	17 ( 61 )	32

## WET-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCDB)

78 / 79	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 95 )	0 ( 0 )	0 ( 0 )	2 ( 95 )	
76 / 77	0 ( 0 )	0 ( 0 )	4 ( 88 )	14 ( 91 )	13 ( 90 )	0 ( 0 )	31 ( 90 )	
74 / 75	1 ( 84 )	1 ( 81 )	26 ( 86 )	22 ( 94 )	18 ( 89 )	13 ( 83 )	81 ( 88 )	
72 / 73	18 ( 76 )	13 ( 76 )	32 ( 87 )	37 ( 92 )	20 ( 90 )	15 ( 81 )	135 ( 86 )	
70 / 71	17 ( 76 )	22 ( 75 )	25 ( 81 )	24 ( 87 )	31 ( 88 )	18 ( 79 )	137 ( 81 )	
68 / 69	17 ( 75 )	17 ( 74 )	22 ( 79 )	18 ( 86 )	28 ( 83 )	22 ( 77 )	124 ( 79 )	
66 / 67	18 ( 73 )	29 ( 71 )	11 ( 78 )	5 ( 85 )	9 ( 80 )	31 ( 74 )	103 ( 74 )	
64 / 65	29 ( 70 )	22 ( 69 )	3 ( 79 )	2 ( 85 )	5 ( 82 )	21 ( 72 )	82 ( 72 )	
62 / 63	15 ( 67 )	11 ( 66 )	1 ( 73 )	0 ( 0 )	0 ( 0 )	3 ( 69 )	30 ( 67 )	
60 / 61	8 ( 65 )	6 ( 64 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 68 )	15 ( 65 )	
58 / 59	1 ( 64 )	3 ( 61 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	4 ( 62 )	

## AVERAGE VALUES:

DRY-BULB AVERAGES	72.2	71.4	83	90	86.4	76.6	79.9	DEG.F
WET-BULB AVERAGES	66.9	67	71	72	71	68.5	69.4	DEG.F
DAILY HORIZONTAL SOLAR		136	838	832	151		1957	BTU/SQ.FT.
WIND SPEED AVERAGES	10	10.2	12.7	12.8	12.7	10.3	11.4	MPH

## WIND FREQUENCIES:

## HOURS OF OCCURRENCE (PREVAILING DIRECTION)

< 5.5 MPH	9 (S)	6 (S)	3 (S)	10 (S)	3 (ENE)	10 (S)	41 (S)
5.5-14.4 MPH	102 (SSE)	104 (SSE)	75 (S)	65 (SSE)	80 (SE)	102 (SSE)	528 (SSE)
14.5-21.0 MPH	13 (SSE)	14 (SSE)	46 (S)	48 (SSE)	39 (SSE)	12 (SSE)	172 (SSE)
>21.0 MPH	0 (*)	0 (*)	0 (*)	1 (SSE)	2 (SSE)	0 (*)	3 (SSE)

## DEGREE HOURS (HEATING/COOLING)

## TIME GROUP

TEMP BASE	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24	TOTAL
75	421 / 78	511 / 63	41 / 1031	5 / 1866	13 / 1423	170 / 373	1161 / 4834
70	124 / 401	147 / 319	1 / 1611	0 / 2481	0 / 2030	25 / 848	297 / 7690
65	5 / 902	28 / 820	0 / 2230	0 / 3101	0 / 2650	0 / 1443	33 / 11146
60	0 / 1517	0 / 1412	0 / 2850	0 / 3721	0 / 3270	0 / 2063	0 / 14833
57	0 / 1889	0 / 1784	0 / 3222	0 / 4093	0 / 3642	0 / 2435	0 / 17065
55	0 / 2137	0 / 2032	0 / 3470	0 / 4341	0 / 3890	0 / 2683	0 / 18553
50	0 / 2757	0 / 2652	0 / 4090	0 / 4961	0 / 4510	0 / 3303	0 / 22273

TEMP BIN	TIME GROUP						HORIZ. SOLAR	
	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24	TOTAL	(BTUH/SQ.FT.)

DRY-BULB TEMPERATURES: HOURS OF OCCURRENCE (MCWB)

95 / 99	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 74 )	0 ( 0 )	0 ( 0 )	1 ( 74 )	163
90 / 94	0 ( 0 )	0 ( 0 )	1 ( 73 )	18 ( 74 )	7 ( 72 )	0 ( 0 )	26 ( 73 )	168
85 / 89	0 ( 0 )	0 ( 0 )	11 ( 74 )	20 ( 73 )	13 ( 72 )	0 ( 0 )	44 ( 73 )	177
80 / 84	0 ( 0 )	0 ( 0 )	22 ( 73 )	28 ( 72 )	25 ( 72 )	5 ( 69 )	80 ( 72 )	167
75 / 79	8 ( 70 )	9 ( 72 )	19 ( 71 )	21 ( 69 )	28 ( 70 )	28 ( 71 )	113 ( 70 )	143
70 / 74	43 ( 69 )	36 ( 70 )	35 ( 68 )	22 ( 63 )	25 ( 66 )	30 ( 69 )	191 ( 68 )	118
65 / 69	38 ( 66 )	41 ( 67 )	18 ( 63 )	5 ( 59 )	11 ( 62 )	36 ( 66 )	149 ( 65 )	70
60 / 64	15 ( 62 )	15 ( 60 )	5 ( 57 )	1 ( 59 )	7 ( 56 )	6 ( 58 )	49 ( 60 )	78
55 / 59	5 ( 53 )	6 ( 54 )	5 ( 56 )	0 ( 0 )	0 ( 0 )	10 ( 53 )	26 ( 54 )	58
50 / 54	9 ( 51 )	10 ( 51 )	4 ( 46 )	4 ( 47 )	4 ( 47 )	5 ( 48 )	36 ( 49 )	48
45 / 49	2 ( 45 )	3 ( 46 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	5 ( 46 )	12

WET-BULB TEMPERATURES: HOURS OF OCCURRENCE (MCDB)

76 / 77	0 ( 0 )	0 ( 0 )	2 ( 86 )	6 ( 90 )	2 ( 86 )	0 ( 0 )	10 ( 88 )	
74 / 75	0 ( 0 )	1 ( 74 )	18 ( 83 )	15 ( 88 )	6 ( 84 )	2 ( 78 )	42 ( 85 )	
72 / 73	7 ( 75 )	8 ( 74 )	26 ( 81 )	41 ( 85 )	26 ( 84 )	13 ( 76 )	121 ( 82 )	
70 / 71	18 ( 73 )	19 ( 73 )	21 ( 74 )	18 ( 77 )	23 ( 81 )	22 ( 75 )	121 ( 76 )	
68 / 69	30 ( 71 )	34 ( 69 )	16 ( 71 )	12 ( 75 )	26 ( 75 )	21 ( 72 )	139 ( 72 )	
66 / 67	21 ( 69 )	18 ( 68 )	10 ( 70 )	4 ( 78 )	11 ( 74 )	26 ( 70 )	90 ( 70 )	
64 / 65	17 ( 66 )	8 ( 65 )	4 ( 70 )	2 ( 76 )	3 ( 70 )	10 ( 66 )	44 ( 67 )	
62 / 63	6 ( 64 )	6 ( 63 )	1 ( 66 )	3 ( 74 )	4 ( 69 )	3 ( 67 )	23 ( 66 )	
60 / 61	5 ( 64 )	3 ( 61 )	2 ( 62 )	3 ( 69 )	3 ( 67 )	4 ( 66 )	20 ( 65 )	
58 / 59	0 ( 0 )	1 ( 62 )	0 ( 0 )	4 ( 68 )	3 ( 66 )	1 ( 61 )	9 ( 66 )	
56 / 57	0 ( 0 )	1 ( 59 )	7 ( 64 )	0 ( 0 )	1 ( 62 )	2 ( 59 )	11 ( 62 )	
54 / 55	1 ( 55 )	4 ( 59 )	5 ( 61 )	8 ( 72 )	6 ( 68 )	5 ( 58 )	29 ( 64 )	
52 / 53	11 ( 55 )	6 ( 57 )	4 ( 65 )	0 ( 0 )	1 ( 64 )	4 ( 58 )	26 ( 58 )	
50 / 51	0 ( 0 )	6 ( 52 )	0 ( 0 )	0 ( 0 )	1 ( 60 )	1 ( 59 )	8 ( 54 )	
48 / 49	0 ( 0 )	2 ( 51 )	0 ( 0 )	1 ( 54 )	0 ( 0 )	3 ( 56 )	6 ( 54 )	
46 / 47	2 ( 51 )	2 ( 49 )	3 ( 51 )	3 ( 52 )	4 ( 53 )	2 ( 53 )	16 ( 51 )	
44 / 45	2 ( 49 )	1 ( 47 )	1 ( 50 )	0 ( 0 )	0 ( 0 )	1 ( 50 )	5 ( 49 )	

AVERAGE VALUES:

DRY-BULB AVERAGES	67.2	66.5	73.8	79.9	76.4	69.6	72.2	DEG.F
WET-BULB AVERAGES	65.1	64.9	67.8	68.9	67.4	65.6	66.6	DEG.F
DAILY HORIZONTAL SOLAR		66	652	729	98		1545	BTU/SQ.FT.
WIND SPEED AVERAGES	11.1	11.4	14.7	14.9	13.4	12.3	13	MPH

WIND FREQUENCIES: HOURS OF OCCURRENCE (PREVAILING DIRECTION)

< 5.5 MPH	5 ( N )	10 ( ESE )	3 ( N )	4 ( NNE )	0 ( * )	0 ( * )	22 ( N )	
5.5-14.4 MPH	89 ( SSE )	77 ( SSE )	64 ( SSE )	48 ( SSE )	71 ( SSE )	89 ( SSE )	438 ( SSE )	
14.5-21.0 MPH	26 ( SSE )	30 ( SSE )	39 ( SSW )	60 ( SSE )	46 ( SSE )	31 ( SSE )	232 ( SSE )	
>21.0 MPH	0 ( * )	3 ( N )	14 ( SSW )	8 ( SSW )	3 ( NNW )	0 ( * )	28 ( SSW )	

TEMP BIN	TIME GROUP						TOTAL	HORIZ. SOLAR (BTUH/SQ.FT.)
	1 - 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24		

## DRY-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCWB)

85 / 89	0 ( 0 )	0 ( 0 )	0 ( 0 )	10 ( 72 )	2 ( 72 )	0 ( 0 )	12 ( 72 )	146
80 / 84	0 ( 0 )	0 ( 0 )	4 ( 70 )	21 ( 65 )	8 ( 67 )	0 ( 0 )	33 ( 66 )	148
75 / 79	0 ( 0 )	0 ( 0 )	15 ( 66 )	24 ( 64 )	19 ( 65 )	2 ( 70 )	60 ( 65 )	149
70 / 74	2 ( 69 )	2 ( 69 )	17 ( 64 )	20 ( 56 )	13 ( 61 )	13 ( 68 )	67 ( 62 )	140
65 / 69	16 ( 65 )	9 ( 66 )	23 ( 57 )	12 ( 54 )	27 ( 56 )	17 ( 58 )	104 ( 59 )	113
60 / 64	25 ( 55 )	23 ( 57 )	20 ( 54 )	15 ( 50 )	16 ( 52 )	29 ( 55 )	128 ( 54 )	101
55 / 59	27 ( 53 )	27 ( 53 )	17 ( 50 )	15 ( 47 )	17 ( 48 )	13 ( 52 )	116 ( 51 )	87
50 / 54	16 ( 49 )	23 ( 49 )	17 ( 45 )	7 ( 45 )	17 ( 45 )	23 ( 48 )	103 ( 47 )	80
45 / 49	24 ( 43 )	22 ( 43 )	10 ( 43 )	0 ( 0 )	5 ( 43 )	23 ( 43 )	84 ( 43 )	47
40 / 44	9 ( 40 )	9 ( 40 )	1 ( 40 )	0 ( 0 )	0 ( 0 )	4 ( 39 )	23 ( 40 )	78
35 / 39	5 ( 36 )	9 ( 37 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	14 ( 37 )	29

## WET-BULB TEMPERATURES:

## HOURS OF OCCURRENCE (MCDB)

72 / 73	0 ( 0 )	0 ( 0 )	2 ( 82 )	8 ( 86 )	2 ( 86 )	0 ( 0 )	12 ( 85 )
70 / 71	0 ( 0 )	0 ( 0 )	10 ( 76 )	4 ( 85 )	5 ( 80 )	8 ( 74 )	27 ( 77 )
68 / 69	5 ( 70 )	4 ( 70 )	1 ( 74 )	5 ( 78 )	4 ( 79 )	3 ( 70 )	22 ( 74 )
66 / 67	6 ( 68 )	4 ( 67 )	2 ( 71 )	7 ( 80 )	6 ( 78 )	2 ( 72 )	27 ( 74 )
64 / 65	1 ( 67 )	4 ( 65 )	10 ( 74 )	12 ( 80 )	3 ( 77 )	3 ( 71 )	33 ( 75 )
62 / 63	4 ( 67 )	2 ( 62 )	11 ( 71 )	12 ( 79 )	10 ( 77 )	3 ( 63 )	42 ( 73 )
60 / 61	8 ( 63 )	7 ( 62 )	8 ( 67 )	7 ( 75 )	15 ( 70 )	6 ( 66 )	51 ( 67 )
58 / 59	0 ( 0 )	3 ( 64 )	8 ( 68 )	7 ( 77 )	7 ( 67 )	4 ( 66 )	29 ( 69 )
56 / 57	13 ( 59 )	7 ( 58 )	6 ( 67 )	6 ( 70 )	7 ( 68 )	19 ( 63 )	58 ( 63 )
54 / 55	15 ( 59 )	16 ( 57 )	11 ( 62 )	7 ( 66 )	6 ( 65 )	9 ( 61 )	64 ( 61 )
52 / 53	6 ( 58 )	11 ( 55 )	3 ( 63 )	15 ( 68 )	11 ( 64 )	4 ( 53 )	50 ( 62 )
50 / 51	15 ( 56 )	10 ( 56 )	8 ( 64 )	5 ( 64 )	10 ( 64 )	14 ( 59 )	62 ( 59 )
48 / 49	8 ( 56 )	8 ( 53 )	13 ( 60 )	9 ( 60 )	10 ( 58 )	9 ( 56 )	57 ( 57 )
46 / 47	4 ( 53 )	4 ( 56 )	6 ( 54 )	9 ( 57 )	8 ( 56 )	5 ( 53 )	36 ( 55 )
44 / 45	4 ( 49 )	4 ( 49 )	13 ( 51 )	11 ( 54 )	16 ( 52 )	14 ( 50 )	62 ( 51 )
42 / 43	20 ( 47 )	24 ( 46 )	11 ( 50 )	0 ( 0 )	2 ( 51 )	12 ( 48 )	69 ( 47 )
40 / 41	7 ( 44 )	4 ( 44 )	1 ( 42 )	0 ( 0 )	2 ( 48 )	6 ( 45 )	20 ( 45 )
38 / 39	3 ( 41 )	5 ( 41 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	1 ( 44 )	9 ( 41 )
36 / 37	5 ( 38 )	5 ( 38 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 41 )	12 ( 38 )
34 / 35	0 ( 0 )	2 ( 36 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	0 ( 0 )	2 ( 36 )

## AVERAGE VALUES:

DRY-BULB AVERAGES	55.1	53.5	63.5	71.2	65.5	58.2	61.2	DEG.F
WET-BULB AVERAGES	51.2	50.4	55.1	57.5	55.2	52.5	53.7	DEG.F
DAILY HORIZONTAL SOLAR		38	555	582	43		1218	BTU/SQ.FT.
WIND SPEED AVERAGES	11	10.6	13.4	14	11.4	11.8	12	MPH

## WIND FREQUENCIES:

## HOURS OF OCCURRENCE (PREVAILING DIRECTION)

< 5.5 MPH	0 ( * )	3 ( N )	6 ( N )	7 ( WNW )	5 ( SSE )	0 ( * )	21 ( WNW )
5.5-14.4 MPH	111 ( S )	107 ( S )	73 ( S )	65 ( S )	94 ( SSE )	100 ( S )	550 ( S )
14.5-21.0 MPH	11 ( S )	11 ( S )	35 ( SSW )	40 ( S )	23 ( SSE )	22 ( SSE )	142 ( S )

## DOMESTIC HOT WATER LOAD CALCULATIONS

**E M C ENGINEERS, INC.**

Denver • Colorado Springs • Atlanta • West Germany

JOB FL SILL CENTRAL PLANT 3002-000

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY KC DATE 3-14-91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE DOMESTIC HW LOAD CALC.BDG 730

THERE ARE 4 BLDG. (CLASSROOM) CONNECTED TO HEATING PLANT.

- 700	146,000	SQ. FT	300	SQ. FT/PERS	=	486	PERS
- 707	77,000	SQ. FT	300	"-"	=	250	"-"
- 730	214,000	SQ. FT	300	"-"	=	713	"-"
- 840	142,000	SQ. FT	300	"-"	=	473	"-"

TOTAL PERS = 1922 PERS

PEAK ENERGY USAGE = BOILER CAPACITY = 2.66 MBTUHENERGY CONSUMPTION

1922 PERS X 1 GAL/PERS-DAY = 1922 GAL/DAY

1922 GAL/DAY X 8.33<sup>#</sup>/GAL X (140°-60°F) = 1280,820 BTU/D.OR = 53,367.53 BTU/HRPEAK ENERGY USAGE

1922 PERS X 0.4 GAL/PERS-HR = 768.8 GAL/HR

768.8 GAL/HR X 8.33<sup>#</sup>/GAL X (140-60°F) = 512,328 BTUH

**E M C ENGINEERS, INC.**

Denver • Colorado Springs • Atlanta • West Germany

JOB 3002-000

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY KC DATE 3-14-91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE DOMESTIC HW LOAD CALC.

BLDG. 9/4

BOILER # 1 SERVE DOMESTIC HW HAS CAPACITY OF 1,610,000 BTUH

∴ PEAK BLDG DOMESTIC HW LOAD = CAP. 1,610,000 BTUH

MESS HALL

140°F 180 MEALS(MAX.)/HR X 1.5 GAL/MEAL. = 270 GAL/HR

180°F 180 MEALS(MAX.)/HR X 1.3 GAL/MEAL = 234 GAL/HR

~~270 GAL/HR X 8.33#/GAL X (140-60°F) = 180,000 BTUH~~

~~234 GAL/HR X 8.33#/GAL X (180-60°F) = 272,900 BTUH~~

~~TOTAL = 452,800 BTUH~~

~~REMAINING FOR DOMESTIC IS: 1.61 - .4528 MBTUH~~

~~= 1.157 MBTUH~~

PEOPLE OCCUPY BLDG

ADMIN - 49 PERS @ 1 GAL/DAY

BARRACK - 274 PERS @ 13.1 GAL/DAY

TOTAL DOMESTIC LOAD IS  $49 + (274 \times 13.1) = 408 \text{ GAL/DAY}$

TOTAL BLDG HW LOAD ARE:

140°F HW -  $(408 + 270) \text{ GAL/DAY} \times 8.33 \text{#/GAL} \times (140-60°F) = 271,891 \text{ BTU/DAY}$

180°F HW -  $(234) \text{ GAL/DAY} \times 8.33 \text{#/GAL} \times (180-60°F) = 233,906 \text{ BTU/DAY}$

TOTAL = 505,797 BTU/DAY

OR 21,074.9 BTU/HR

**E M C ENGINEERS, INC.**

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JOB 3002-000

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY KC DATE 3/13/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE DOMESTIC HW LOAD CALC.BLDG 2812

13 BARRACKS @ 13,000 SQ. FT. = 169,000 SQ. FT.

1 MESS HALL @ 9,000 SQ. FT. = 9,000 SQ. FT.

BARRACK (170 SQ. FT./PER) = 169,000/170 ≈ 995 PERSMESS HALL~~375 MEALS (MAX)/HR X 1.5 GAL/MEAL = 562 GPH (140°F)~~~~375 MEALS (MAX)/HR X 1.3 GAL/MEAL = 491 GPH (180°F)~~PEAK ENERGY USAGE

DOMESTIC HW

3.8 GAL/PERS-HR X 995 PERS = 3,781 GPH

140°F (3,781 + 562) GPH X 8.33#/GAL X (140-60°F) = 2,519,658 BTUH

~~180°F (491) GPH X 8.33#/GAL X (180-40°F) = 572,604 BTUH~~TOTAL = 2,519,658 BTUHENERGY CONSUMPTION

BARRACK 13.1 GAL/DAY-PERS X 995 = 13,035 /DAY

~~MESS HALL 3 MEAL/DAY~~~~3 X 375 MEALS (MAX)/DAY X 2.4 GAL/MEAL = 2,700 GAL/DAY~~~~3 X 375 MEALS (MAX)/DAY X 1.3 GAL/MEAL = 1,473 GAL/DAY~~

140°F HW - (13,035 + 2,700) GAL/DAY X 8.33#/DAY X (140-60°F) = 8,686,524 BTU/DAY

~~180°F HW - 1,473 GAL/DAY X 8.33#/GAL X (180-40°F) = 1,717,813 BTU/DAY~~

TOTAL = 8,686,524 BTU/DAY

OR = 361,938 BTU/HR

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CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE DOMESTIC HW LOAD CALC.

BLDG 2812 MESS HALL KITCHEN LOAD

PEAK OF KITCHEN LOAD EQUAL BOILER MAX. OUTPUT  
2.25 MBH

ENERGY CONSUMPTION.

$$3 \times 375 \text{ MEALS (MAX.) / DAY} \times 2.4 \text{ GAL / MEAL-DAY} = 2700 \text{ GPD } 140^{\circ}\text{F}$$

$$3 \times 375 \text{ MEALS (MAX.) / DAY} \times 2 \text{ GAL / MEAL-DAY} = 2250 \text{ GPD } 180^{\circ}\text{F}$$

$$140^{\circ}\text{F} \quad 2700 \text{ GPD} \times 8.33^{\circ}\text{F / GAL} \times (140^{\circ}\text{F} - 60^{\circ}\text{F}) = 1,799,280 \text{ BTU / DAY}$$

$$180^{\circ}\text{F} \quad 2250 \text{ GPD} \times 8.33^{\circ}\text{F / GAL} \times (180^{\circ}\text{F} - 60^{\circ}\text{F}) = 2,249,100 \text{ BTU / DAY}$$

$$\text{TOTAL} = \underline{4,048,380 \text{ BTU / DAY}}$$

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CALCULATED BY KC DATE 3-20-91  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE DOMESTIC HW LOAD CALC.

BLDG 4701

SERVE BLDG 4700 WHICH HAS SQ. FT. OF 197,200

PEAK ENERGY CALC.

KITCHEN HW (ESTIMATE):

COOKING 375 MEALS (MAX.)/HR X 1.5 GAL/MEAL = 562 GPH 140°F  
WASHING 375 MEALS (MAX.)/HR X 1.3 GAL/MEAL = 491 GPH 180°F

DOMESTIC HW. (ESTIMATE):

NO. OF PEOPLE IN BLDG =  $\frac{197,200 \text{ SQ. FT.}}{250 \text{ SQ. FT./PER}} = 789.$

789 PERS X 0.4 GAL/PER-HR = 315.6 GPH

140°F (562+315.6) GPH X 8.33#/GAL X (140-60°F) = 584,833 BTU/HR.

180°F 491 GPH X 8.33#/GAL X (180-60°F) = 490,803 BTU/HR

TOTAL = 1,075,636 BTU/HR

ENERGY CONSUMPTION CALC.

KITCHEN HW (ESTIMATE):

COOKING 2X375 MEALS (MAX.)/DAY X 2.4 GAL/MEAL = 1800 GPD 140°F

WASHING 2X375 MEALS (MAX.)/DAY X 2 GAL/MEAL = 1500 GPD 180°F

DOMESTIC HW (ESTIMATE):

789 PERS X 1 GAL/PER-DAY = 789 GAL

140°F (1800+789) GPD X 8.33#/GAL X (140-60°F) = 1,725,309 BTU/DAY

180°F 1500 GPD X 8.33#/GAL X (180-60°F) = 1,499,400 BTU/DAY

TOTAL = 3,224,709 BTU/DAY

OR = 134,363 BTU/HR

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SCALE DOMESTIC HW LOAD CALC.

BLDG 5900

BLDG	SQ. FT. BARRACK -	SQ. FT. ADMIN	SQ. FT. MESS HALL
6007	189,300	19,000	12,500
6050			
5955			
5960			
5970			
	↓	↓	↓
	<u>946,500</u>	<u>95,000</u>	<u>62,500</u>

BARRACK 170 SQ. FT./PERS =  $946,500 / 170 = 5,568$  PERS

ADMIN 250 SQ. FT./PERS =  $95,000 / 250 = 380$  PERS

KITCHEN

140°F HW: 187 MEALS (MAX.)/HR. X 1.5 GAL/MEAL  
= 281 GPH

180°F HW: 187 MEALS (MAX.)/HR X 1.3 GAL/MEAL  
= 246 GPH

PEAK ENERGY USAGE

3.8 GAL/PERS-HR X 5568 PERS = 21,158 GPH

0.4 GAL/PERS-HR X 380 PERS = 152 GPH

TOTAL = 21,310 GPH

140°F HW:  

$$[(5 \times 281) + (21,310 \text{ GPH})] \times 8.33 \text{ #/GAL} \times (140^\circ\text{F} - 60^\circ\text{F}) = 15,137,276 \text{ BTUH}$$

180°F HW  

$$5 \times [(246) \text{ GPH} \times 8.33 \text{ #/GAL} \times (180^\circ\text{F} - 40^\circ\text{F})] = 1,434,462 \text{ BTUH}$$

TOTAL = 16,571,702 BTUH  
16,571,700 BTUH

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CALCULATED BY KL DATE 3/13/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE DOMESTIC HW LOAD CALC.

BLDG 5900 (CONTINUED)

BARRACK 13.1 GAL/DAY-PERS X 5568 PERS = 72,940 GAL/DAY

ADMIN 1 GAL/DAY-PERS X 380 PERS = 380 GAL/DAY

KITCHEN:

140°F 3 X 187 MEALS/DAY 2.4 GAL/MEAL = 1350 GAL/DAY

180°F 3 X 187 MEALS/DAY X 1.3 GAL/MEAL = 731 GAL/DAY

ENERGY CONSUMPTION

140°F 72940 + 380 + 1350 GAL/DAY X 8.33#/GAL X (140-60°F) = 49,760,000 BTU/DAY

180°F 731 GAL/DAY X 8.33 GAL/DAY X (180-40°F) = 852,500 BTU/DAY

TOTAL = 50,612,580 BTU/DAY

OR = 2108,857 BTU/HR

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CALCULATED BY KC DATE 3/13/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE DOMESTIC HW LOAD CALC.

BLDG 6003DOMESTIC HW (ESTIMATE):

		SQ. FT.			SQ. FT.
6001	BARRACK	35,000	6002	ADMIN	23,000
6010	↓	35,000	6004	" "	23,000
6012	↓	78,000		TOTAL	46,000
6014	↓	35,000			
6015	↓	35,000	6120	CLASS ROOM	16,000
6017	↓	69,000	6080	STORE HOUSE	1,300
6018	↓	69,000		TOTAL	17,300
	TOTAL	356,000 SQ. FT.	6011	MESS HALL	2,000

$$\begin{aligned}
 \text{BARRACK (170 SQ. FT./PERS)} & : 356,000 \text{ SQ. FT.} = \underline{2100} \text{ PERS} \\
 \text{ADMIN (250 SQ. FT./PERS)} & : 46,000 \text{ SQ. FT.} = \underline{185} \text{ PERS} \\
 \text{CLASSROOM (300 SQ. FT./PERS)} & : 17,300 \text{ SQ. FT.} = \underline{58} \text{ PERS} \\
 \text{[ADMIN/CLASSROOM] TOTAL} & = \underline{243} \text{ PERS}
 \end{aligned}$$

MESSHALL KITCHEN

$$\begin{aligned}
 (140^{\circ}\text{F HW}) \quad 375 \text{ MEAL (MAX.)/HR} \times 1.5 \text{ GAL/MEAL} & = 562 \text{ GPH} \\
 (180^{\circ}\text{F HW}) \quad 375 \text{ MEAL (MAX.)/HR} \times 1.3 \text{ GAL/MEAL} & = 491 \text{ GPH}
 \end{aligned}$$

DOMESTIC HW

$$\begin{aligned}
 \text{BARRACK (140}^{\circ}\text{F HW)} \quad 3.8 \text{ GAL/PERS-HR} \times 2100 \text{ PERS} & = 7980 \text{ GPH} \\
 \text{ADMIN/CLAS ROOM} \quad 0.4 \text{ GAL/PERS-HR} \times 243 \text{ PERS} & = \underline{97} \text{ GPH} \\
 \text{PEAK ENERGY USAGE} & = \underline{8077} \text{ GPH}
 \end{aligned}$$

$$\begin{aligned}
 [140^{\circ}\text{F HW}] \quad (562 + 8077) \times 8.33 \text{ \#/GAL} \times (140^{\circ}\text{F} - 60^{\circ}\text{F}) & = 5,757,030 \text{ BTUH} \\
 [180^{\circ}\text{F HW}] \quad 491 \text{ GPH} \times 8.33 \text{ \#/GAL} \times (180^{\circ}\text{F} - 40^{\circ}\text{F}) & = \underline{572,604} \text{ BTUH}
 \end{aligned}$$

$$\text{TOTAL} = \underline{6,330,000} \text{ BTUH}$$

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CALCULATED BY KC DATE 3/13/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE DOMESTIC HW LOAD CALC.BLDG 6003 (CONTINUED)BARRACK

13.1 GAL/DAY/PERS X 2100 PERS = 27,510 GAL/DAY  
ADMIN/CLASS ROOM

1 GAL/DAY/PERS X 243 PERS = 243 GAL/DAY

MESS HALL 3-MEALS/DAY

140°F 3 X 375 MEALS/DAY X 2.4 GAL/MEAL = 2700 GAL/DAY

180°F 3 X 375 MEALS/DAY X 1.3 GAL/MEAL = 1462 GAL/DAY

ENERGY CONSUMPTION

140°F 27510 + 243 + 2700 GAL/DAY X 8.33#/GAL X (140°F - 60°F)  
= 20,293,879 BTU/DAY

180°F 1462 GAL/DAY X 8.33#/GAL X (180°F - 40°F) = 1,704,984 BTU/DAY

TOTAL = 21,998,863 BTU/DAY

OR = 916,619 BTU/HR

## DISTRIBUTION LOSS CALCULATIONS

**JOB**

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SHEET NO.

CALCULATED BY

CHECKED BY

SCALE

## DISTRIBUTION

1991

JAN 31 DAYS

FEB 28 672

MAR 31 744

APR 30 720

MAY 31 744

JUN 30 720

JUL 31 744

AUG 31 744

SEP 30 720

OCT 3 1974

NOV	30	720
-----	----	-----

DEC 31 744

8760

730 - HEATING 156,400 BTU/H

2812 - HEATING 240,800 BTU/H

4701 - HEATING 11,160 BTU/H

5900 - HEATING 3,530,000 BTU/H

6003 - HEATING 1,553,400 BTU/H

# **E M C ENGINEERS, INC.**

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JOB 3002.000

SHEET NO. \_\_\_\_\_

OF \_\_\_\_\_

CALCULATED BY JW

DATE 3/12/91

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE \_\_\_\_\_

5900  
HWS

$$q = \frac{2\pi(10,714)(350-60)}{\frac{\ln\left(\frac{r_1}{r_a}\right)}{28} + \frac{\ln\left(\frac{r_c}{r_b}\right)}{.45} + \frac{1}{.635(.21)}}$$

$$= 2.133 \text{ MBTU/HR}$$

HWR

$$q = \frac{2\pi(10,714)(250-60)}{9.1538}$$

$$= 1.3973 \text{ MBTU/HR}$$

$$\boxed{\text{H/W TOTAL} = 3.530 \text{ MBTU/HR}}$$

CWS

$$q = \frac{2\pi(10,714)(40-60)}{\frac{\ln\left(\frac{r_1}{r_a}\right)}{28} + \frac{\ln\left(\frac{r_c}{r_b}\right)}{.45} + \frac{1}{r_c(.21)}}$$

$$= 0.1783 \text{ MBTU/HR} = 14.86 \text{ TONS}$$

CWR

$$q = \frac{2\pi(10,714)(50-60)}{7.5495}$$

$$= 0.08917 \text{ MBTU/HR} = 7.4307 \text{ TONS}$$

$$\boxed{\text{C/W TOTAL} = 22.292 \text{ TON}} = 0.2675 \text{ MBTU/HR}$$

6.5" PIPE

PIPE THICKNESS = .031

$$r_a = \frac{.5417}{2} = .2708'$$

$$r_b = \frac{.5417 + 2(.031)}{2} = .3019'$$

$$r_c = \frac{.5417 + 2(.031) + 2(.33)}{2} = .6352'$$

9.5" PIPE

$$r_a = \frac{.792}{2} = .3958'$$

$$r_b = \frac{.792 + 2(.031)}{2} = .4268'$$

$$r_c = \frac{.792 + 2(.031) + 2(.33)}{2} = .7602'$$

# **E M C ENGINEERS, INC.**

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JOB 3002.000

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 3/12/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

BLDG 6003

STMS

$$q = \frac{2\pi(7300)(250-60)}{\frac{\ln\left(\frac{r_a}{r_b}\right)}{28} + \frac{\ln\left(\frac{r_b}{r_c}\right)}{.45} + \frac{1}{.6352(.21)}}$$

$$= 0.9521 \text{ MBTU/HR}$$

STM R

$$q = \frac{2\pi(7300)(180-60)}{9.1538}$$

$$= 0.6013 \text{ MBTU/HR}$$

$$\boxed{\text{STM TOTAL} = 1.5534 \text{ MBTU/HR}}$$

CWS

$$q = 2\pi(6500)(48-60) / A$$

6.5" PIPE (AVG)

PIPE THICKNESS = .031'

$$r_a = \frac{.5417}{2} = .2708'$$

$$r_b = \frac{.5417 + 2(.031)}{2} = .3019'$$

$$r_c = \frac{.5417 + 2(.031) + 2(.33)}{2} = .6352'$$

BLDG 2812

HWS

$$q = \frac{2\pi(4110)(190-60)}{\frac{\ln\left(\frac{r_a}{r_b}\right)}{28} + \frac{\ln\left(\frac{r_b}{r_c}\right)}{.45} + \frac{1}{.2294(.21)}}$$

$$q = 0.1491 \text{ MBTU/HR}$$

HWR

$$q = \frac{2\pi(4110)(140-60)}{22.518}$$

$$q = 0.09175 \text{ MBTU/HR}$$

$$\boxed{\text{TOTAL PIPE LOSSES} = 0.2408 \text{ MBTU/HR}}$$

2" PIPE (AVG)

PIPE THICK. = .021'  
INSUL THICK = 1.5"

$$r_a = \frac{.1667}{2} = 0.0833'$$

$$r_b = \frac{.1667 + 2(.021)}{2} = 0.1043'$$

$$r_c = \frac{.1667 + 2(.021) + 2(1.25)}{2} = .2294'$$

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 3/12/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

730 ASHRAE 22.19  
TO  
700  $\downarrow$   
$$\frac{26 \text{ BTU}}{\text{HR} \cdot \text{ft}} (1080 \text{ ft}) = 28,080 \text{ BTU/hr}$$

FROM  
700  $\frac{20 \text{ BTU}}{\text{HR} \cdot \text{ft}} (1080 \text{ ft}) = 21,600 \text{ BTU/hr}$

TO  
840  $\frac{26 \text{ BTU}}{\text{HR} \cdot \text{ft}} (1120 \text{ ft}) = 29,120 \text{ BTU/hr}$

FROM  
840  $\frac{20 \text{ BTU}}{\text{HR}} (1120) = 22,400 \text{ BTU/hr}$

TO  
707  $\frac{26 \text{ BTU}}{\text{HR}} (1200) = 31,200 \text{ BTU/hr}$

FROM  
707  $\frac{20 \text{ BTU}}{\text{HR}} (1200) = 24,000 \text{ BTU/hr}$

TOTAL PIPING = 156,400 BTU/hr  
HEAT LOSSES  
FOR HW

BLDG 4701

INSUL THICKNESS 3.5" 4.5" PIPE AVG

STMS  $\frac{42 \text{ BTU}}{\text{HR} \cdot \text{ft}} (180 \text{ ft}) = 7,560 \text{ BTU/hr}$

STM R  $\frac{20 \text{ BTU}}{\text{HR} \cdot \text{ft}} (180 \text{ ft}) = 3,600 \text{ BTU/hr}$

TOTAL = 11,160 BTU/hr

**ELECTRICAL ENERGY RATE CALCULATION**

# ELECTRICAL ENERGY RATE CALCULATION

SERVICE MONTHS FY 90	ELECTRICAL ENERGY TOTAL (kWh)	FEDERAL GENERATED ENERGY (kWh)	THERMAL ENERGY (kWh)	FEDERAL GENERATED ENERGY COST (\$)	THERMAL ENERGY COST (\$)	ELECTRIC ENERGY RATE (\$/kWh)	ELECTRIC ENERGY RATE COMMENT
[A]	[B]	[C]	[D]	[H]	[I]	[M]	
OCT '89	10,859,520	9,758,900	1,100,620	\$39,035.60	\$26,965.19	0.0245	COLUMN [I]/[D]
NOV	9,049,600	4,630,583	4,419,017	\$18,522.33	\$105,406.81	0.0239	COLUMN [I]/[D]
DEC	10,146,864	0	10,146,864	\$0.00	\$241,251.84	0.0238	COLUMN [I]/[D]
JAN '90	11,481,680	7,041,950	4,439,730	\$28,167.80	\$94,339.83	0.0212	COLUMN [I]/[D]
FEB	9,377,648	9,377,648	0	\$37,510.59	\$0.00	0.0040	COLUMN [H]/[B]
MAR	10,158,176	10,158,176	0	\$40,632.70	\$0.00	0.0040	COLUMN [H]/[B]
APR	9,527,263	9,527,263	0	\$38,109.05	\$0.00	0.0040	COLUMN [H]/[B]
MAY	11,453,400	11,453,400	0	\$45,813.60	\$0.00	0.0040	COLUMN [H]/[B]
JUN	17,358,264	17,358,264	0	\$69,433.06	\$0.00	0.0040	COLUMN [H]/[B]
JUL	17,884,272	17,884,272	0	\$71,537.09	\$0.00	0.0040	COLUMN [H]/[B]
AUG	18,376,344	10,444,935	7,931,409	\$41,779.74	\$199,704.95	0.0252	COLUMN [I]/[D]
SEP	16,170,504	5,437,224	10,733,280	\$21,748.90	\$240,071.27	0.0224	COLUMN [I]/[D]
					<b>AVERAGE</b>	<b>0.0137</b>	

COMMENT: ON MONTHS WHERE THERE ARE THERMAL ENERGY CHARGES, THE ELECTRICAL ENERGY RATES IS COLUMN [I] DIVIDED BY COLUMN [D]  
ON MONTHS WHERE THERE ARE NO THERMAL ENERGY CHARGES THE ELECTRICAL ENERGY RATE IS COLUMN [H] DIVIDED BY COLUMN [B].

**APPENDIX C**

**CENTRAL PLANT EFFICIENCY CALCULATIONS**

**APPENDIX C.1**

**CHILLERS EFFICIENCY CALCULATIONS**

**CHILLER TESTED CAPACITY**

## CHILLER TEST CAPACITY

Chiller Information			Rated Values					Measured Values						
Bldg No.	Chiller No.	Supplier	(TONS)	(MBH)	In	Temp Avg CHWR (°F)	Temp Avg CHWS (°F)	GPM	In (kW)	Out (Tons)	Calculate (kW/Tons)	Out (MBH)	Percent Load	Elec. Acc. (kW)
			800	9600	640kW	61	49.9	1364	564.00	630.85	0.89	7570	79%	224.00
730	1	TRANE	320	3840	N/A	57.66	43	472.5	214.60	288.62	0.74	3463	90%	89.60
730	3	TRANE	320	3840	NO									89.60
914	1	TRANE	400	4800	240kW	50.82	46.44	726	163.00	132.50	1.23	1590	33%	112.00
2812	1	CARRIER	372	4464	NO	49.7	41.8	530	143.00	174.46	0.82	2094	47%	104.16
3442	1	TRANE	600	7200	360kW	54.53	45.18	1132	297.80	441.01	0.68	5292	74%	168.00
3442	2	TRANE	600	7200	360kW	55.47	45.38	1216.8	309.90	511.56	0.61	6139	85%	168.00
4701	1	CARRIER	275	3300	N/A	47.8	42	535	169.70	129.29	1.31	1551	47%	77.00
4701	2	CARRIER	275	3300	N/A	48.5	43.5	690	105.40	143.75	0.73	1725	52%	77.00
5676	1	CARRIER	170	2040	N/A	56.4	52.4	468	119.50	78.00	1.53	936	46%	47.60
5678	1	TRANE	190	2280	143kW	57.7	53.5	892	106.00	156.10	0.68	1873	82%	53.20
5900	1	CARRIER	400	4800	N/A	58.95	46.18	676	324.00	359.69	0.90	4316	90%	112.00
5900	2	WESTINGHO	400	4800	316kW	52.5	41.7	728.2	309.00	327.69	0.94	3932	82%	112.00
5900	3	CARRIER	400	4800	284kW	54.4	45.1	717	230.80	277.84	0.83	3334	69%	112.00
5900	4	McQUAY	450	5400	352kW	53.95	43.44	854	344.70	373.98	0.92	4488	83%	126.00
5900	5	CARREY	400	4800	272kW	53.3	42.77	640.5	238.00	281.02	0.85	3372	70%	112.00
6003	1	TRANE	400	4800	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0%	112.00
6003	2	TRANE	450	5400	270kW	N/A	N/A	540	N/A	N/A	N/A	0	0%	126.00
6003	3	TRANE	450	5400	270kW	N/A	N/A	540	N/A	N/A	N/A	0	0%	126.00

## CHILLER AUXILIARY LOAD CALCULATIONS

## CHILLER AUX. LOADS

BUILDING NUMBER	CHILLER NO.	CHILLED WATER PUMP (kW)	CONDENSER WATER PUMP (kW)	COOLING TOWER (kW)	TOTAL AUX. LOADS (kW)
730	1	91.0	37.2	23.0	279.9
		93.0	35.7		
	3	20.2	25.4	8.6	54.2
	4				NA
<b>TOTAL</b>		204.2	98.3	31.6	334.1
914	1	29.8	9.4	8.6	47.8
2812	1	14.4	17.8	11.8	44.0
3442	1	44.0	24.0	24.0	92.0
	2	43.8	22.1	24.0	89.9
<b>TOTAL</b>		87.8	46.1	48.0	181.9
4701	1	33.1	24.8	10.5	68.4
	2			10.0	10.0
<b>TOTAL</b>		33.1	24.8	20.5	78.4
5676	1	8.0	7.0	5.4	20.4
5678	1	13.8	6.0	5.4	25.2
5900	1	39.5	17.6	19.2	76.3
	2	38.7	23.0	14.2	75.9
	3	41.9	24.1	14.0	80.0
	4	54.1	26.6	20.2	100.9
	5	43.6	22.0	17.1	82.7
<b>TOTAL</b>		217.8	113.3	84.7	415.8
6003	1				NA
	2	26.6	19.0	18.0	63.6
	3	28.0	19.0	18.0	65.0
<b>TOTAL</b>		54.6	38.0	36.0	128.6

[CHILAU.XWK3]

## CHILLER OUTPUT CALCULATIONS

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

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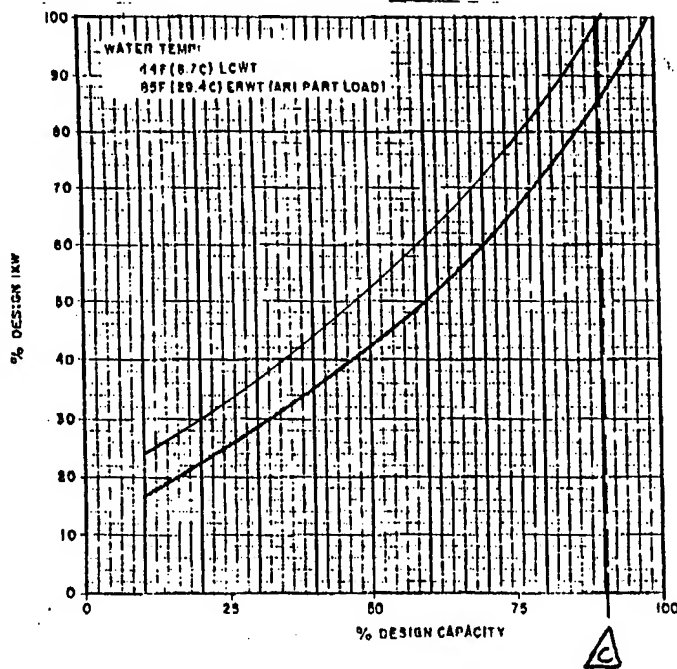
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SCALE \_\_\_\_\_

## **CHILLER OUTPUT CALCULATIONS**

AT 90% EFFICIENCY

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 914

Chiller No.: 1

Chiller Mfg.: TRANE

#### **Design Rating:**

Tons: 400 MBtu: 4800  
Amps: 354 Volts: 460

#### **Test Reading:**

kW: NA Tons: NA  
PF: 88

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 354 \times .88}{1000}$$

$$= \underline{248} \text{ kW}$$

$$\text{Tested kW Input} = \underline{NA} \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{NA}{248} = \underline{NA} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{NA}{400} = \underline{NA} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (A):

$$\underline{90} \% \times \text{Rated Tons} = \underline{.9 \times 400}$$

$$= \underline{360} \text{ Tons; or } \underline{4320} \text{ MBtu}$$

Max. Output MBtu: 4320 MBtu  
Max. kW Input: 248 kW

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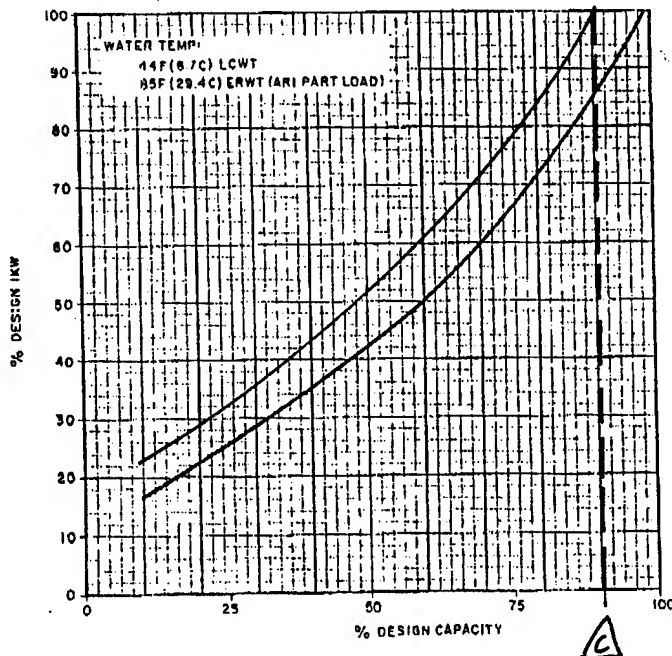
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## **CHILLER OUTPUT CALCULATIONS**

AT 90% EFFICIENCY

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 5676

Chiller No.: 1

Chiller Mfg.: CARRIER

#### **Design Rating:**

Tons: 170 MBtu: 4500  
Amps: 211 Volts: 460

#### **Test Reading:**

kW: N/A Tons: N/A  
PF: 87

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 211 \times .87}{1000} = 146.3 \text{ kW}$$

$$\text{Tested kW Input} = \text{N/A} \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{\text{N/A}}{146.3} = \text{N/A} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{\text{N/A}}{170} = \text{N/A} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):

$$\frac{90}{100} \% \times \text{Rated Tons} = \frac{.9 \times 170}{1} = 153 \text{ Tons; or } 1836 \text{ MBtu}$$

Max. Output MBtu: 1836 MBtu  
Max. kW Input: 146.3 kW

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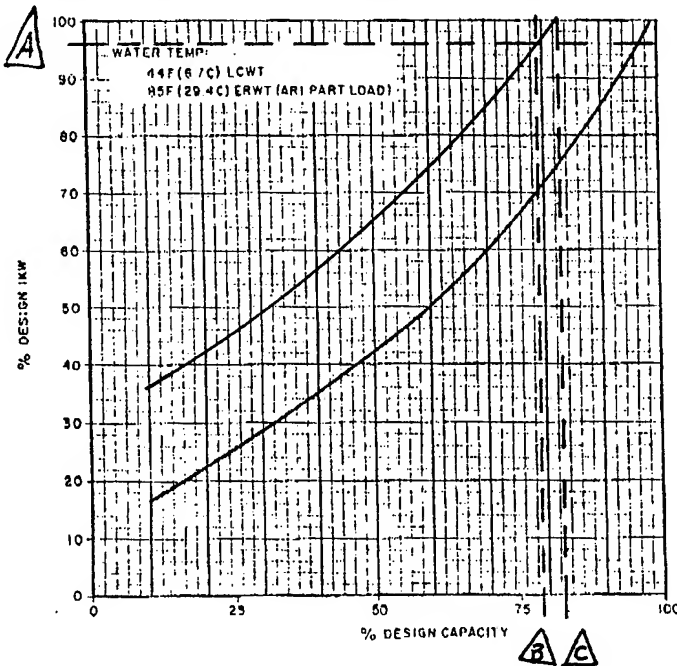
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**CHILLER OUTPUT CALCULATIONS****TYPICAL PART LOAD PERFORMANCE CURVE**Building No.: 730Chiller No.: 1Chiller Mfg.: TRANE**Design Rating:**Tons: 800 MBtu: 9600Amps: 821 Volts: 460**Test Reading:**kW: 564 Tons: 631PF: 90**Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 821 \times .9}{1000}$$

$$= \underline{589} \text{ kW}$$

$$\text{Tested kW Input} = \underline{564} \text{ kW}$$

**From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{564}{589} = \underline{95.8} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{631}{800} = \underline{79} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (A):

$$\underline{83} \% \times \text{Rated Tons} = \underline{.83 \times 800} = \underline{664} \text{ Tons; or } \underline{7968} \text{ MBtu}$$

**Max. Output MBtu:** 7968 MBtu  
**Max. kW Input:** 589 kW

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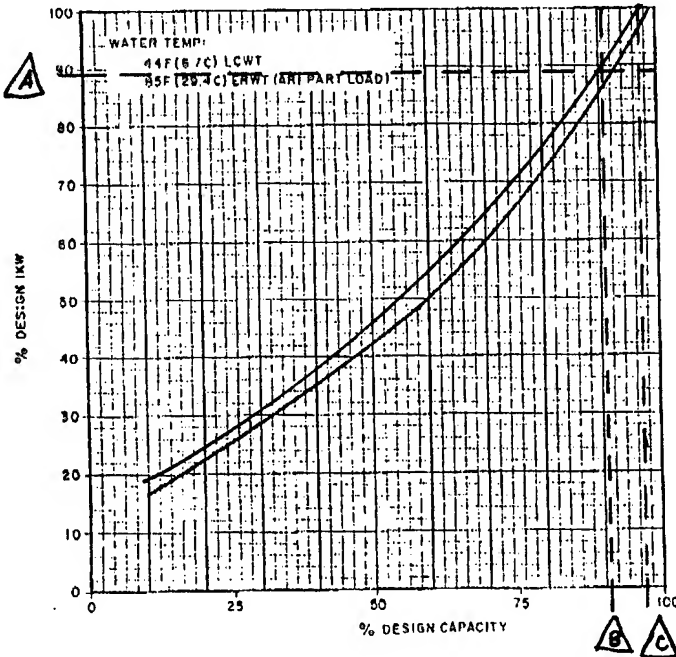
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## **CHILLER OUTPUT CALCULATIONS**

**TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 730  
Chiller No.: 3 (NORTH)  
Chiller Mfg.: TRANE

**Design Rating:**

Tons: 320 MBtu: 3840  
Amps: 367 Volts: 480

**Test Reading:**

kW: 214.6 Tons: 288.6  
PF: 80

**Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 480 \times 367 \times .8}{1000} = 244.1 \text{ kW}$$

$$\text{Tested kW Input} = 214.6 \text{ kW}$$

**From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{214.6}{244.1} = 88 \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{288.6}{320} = 90.2 \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):  
97 % X Rated Tons = .97 X 320  
= 310 Tons; or 3725 MBtu

**Max. Output MBtu:** 3725 MBtu  
**Max. kW Input:** 244 kW

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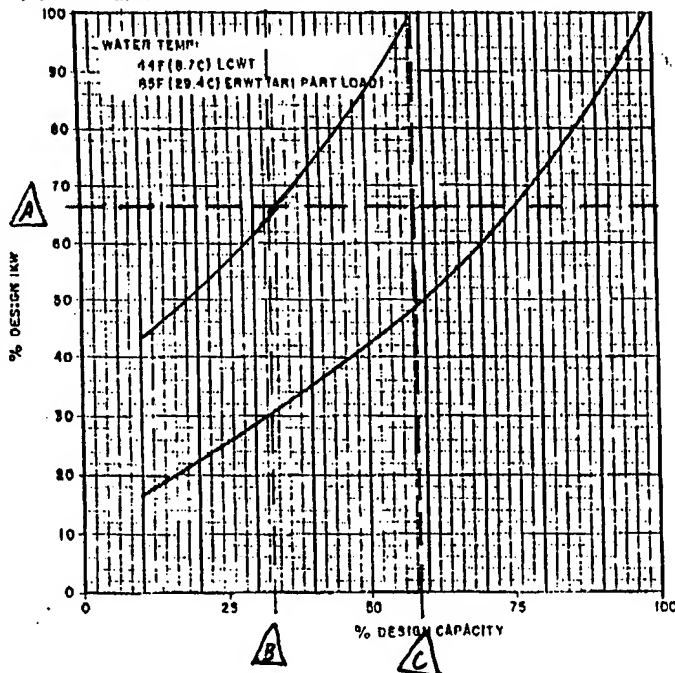
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## **CHILLER OUTPUT CALCULATIONS**

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 914

Chiller No.: 1

Chiller Mfg.: TRANE

#### **Design Rating:**

Tons: 400 MBtu: 4800

Amps: 354 Volts: 460

#### **Test Reading:**

kW: 163 Tons: 133

PF: .88

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 354 \times .88}{1000}$$

$$= \frac{248}{1000} \text{ kW}$$

$$\text{Tested kW Input} = \frac{163}{1000} \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{163}{248} = 66 \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{133}{400} = 33 \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):

$$\frac{58}{100} \% \times \text{Rated Tons} = \frac{.58 \times 400}{100} = 232 \text{ Tons; or } 2784 \text{ MBtu}$$

Max. Output MBtu: 2784 MBtu

Max. kW Input: 248 kW

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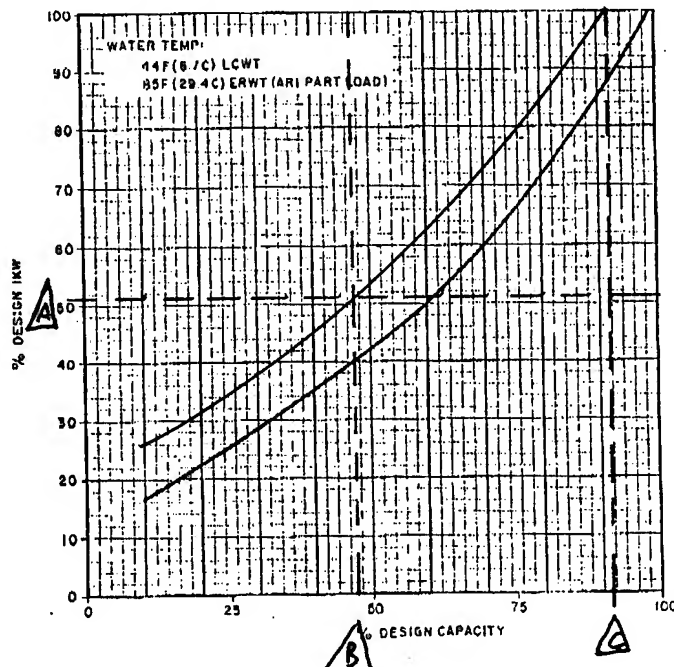
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SCALE \_\_\_\_\_

## **CHILLER OUTPUT CALCULATIONS**

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 2812  
Chiller No.: 1  
Chiller Mfg.: CARRIER

#### **Design Rating:**

Tons: 372 MBtu: 4464  
Amps: 410 Volts: 480

#### **Test Reading:**

kW: 143 Tons: 174.5  
PF: 81.3

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 480 \times 410 \times .813}{1000} = 277 \text{ kW}$$

$$\text{Tested kW Input} = 143 \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{143}{277} = 51.6 \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{174.5}{372} = 47 \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):  
92 % X Rated Tons = .92 X 372  
= 342 Tons; or 4107 MBtu

Max. Output MBtu: 4107 MBtu  
Max. kW Input: 277 kW

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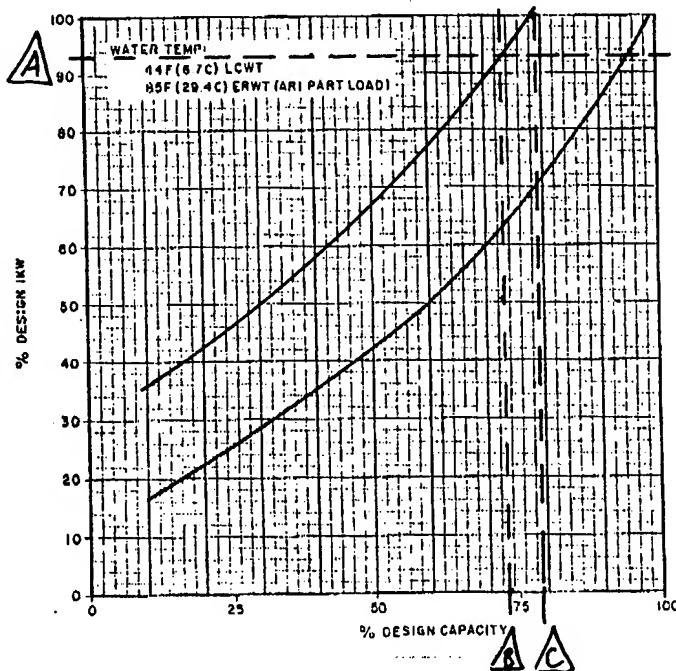
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## **CHILLER OUTPUT CALCULATIONS**

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 3442

Chiller No.: 1

Chiller Mfg.: TRANE

#### **Design Rating:**

Tons: 600 MBtu: 7200  
Amps: 502 Volts: 460

#### **Test Reading:**

kW: 297.8 Tons: 441  
PF: 80

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 502 \times .8}{1000}$$

$$= \frac{320}{1000} \text{ kW}$$

$$\text{Tested kW Input} = \frac{297.8}{1000} \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{297.8}{320} = 93 \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{441}{600} = 73.5 \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):

$$\frac{80}{100} \% \times \text{Rated Tons} = \frac{.8 \times 600}{100} = 480 \text{ Tons; or } 5760 \text{ MBtu}$$

Max. Output MBtu: 5760 MBtu  
Max. kW Input: 320 kW

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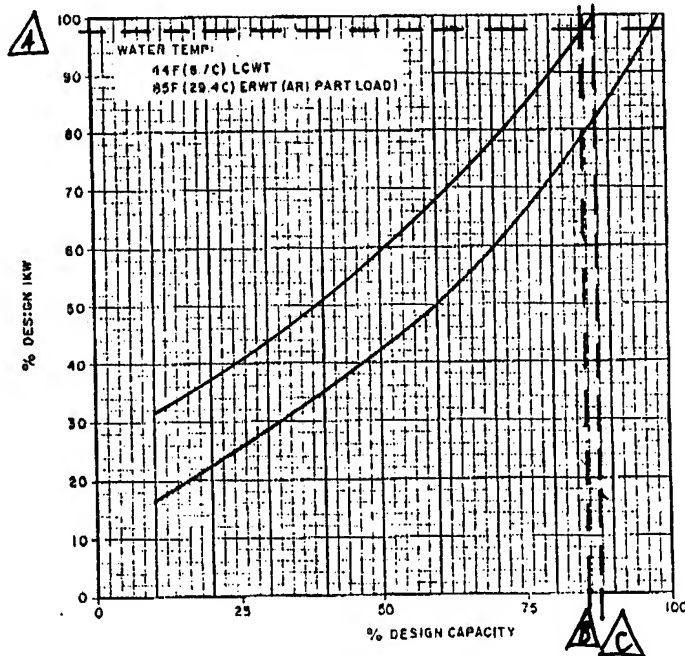
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SCALE \_\_\_\_\_

## **CHILLER OUTPUT CALCULATIONS**

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 3442

Chiller No.: 2

Chiller Mfg.: TRANE

#### **Design Rating:**

Tons: 600 MBtu: 7200

Amps: 502 Volts: 460

#### **Test Reading:**

kW: 310 Tons: 512

PF: 80

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 502 \times .8}{1000}$$

$$= \underline{320} \text{ kW}$$

$$\text{Tested kW Input} = \underline{310} \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{310}{320} = \underline{96.9} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{512}{600} = \underline{85.3} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (A):

$$\underline{88} \% \times \text{Rated Tons} = \underline{.88 \times 600} = \underline{528} \text{ Tons; or } \underline{6336} \text{ MBtu}$$

**Max. Output MBtu:** 6336 MBtu

**Max. kW Input:** 320 kW

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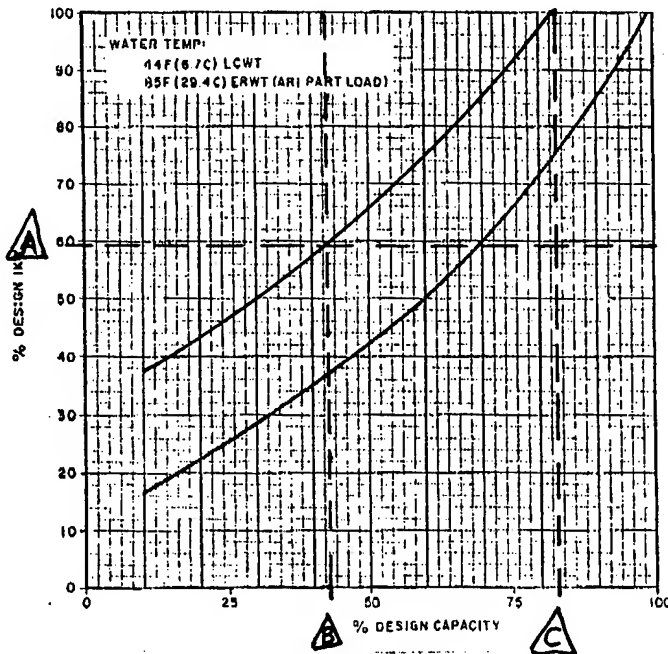
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SCALE \_\_\_\_\_

**CHILLER OUTPUT CALCULATIONS****TYPICAL PART LOAD PERFORMANCE CURVE**
 Building No.: 4701  
 Chiller No.: 1  
 Chiller Mfg.: CARRIER
**Design Rating:**
 Tons: 305 MBtu: 3660  
 Amps: 378 Volts: 460
**Test Reading:**
 kW: 169.7 Tons: 129.3  
 PF: 95.3
**Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 378 \times 95.3}{1000}$$

$$= \frac{287}{1000} \text{ kW}$$

$$\text{Tested kW Input} = \frac{169.7}{1000} \text{ kW}$$

**From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{169.7}{287} = 59\%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{129.3}{305} = 42\%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (A):

$$\frac{83}{100} \% \times \text{Rated Tons} = \frac{.83 \times 305}{100}$$

$$= 253 \text{ Tons; or } 3038 \text{ MBtu}$$

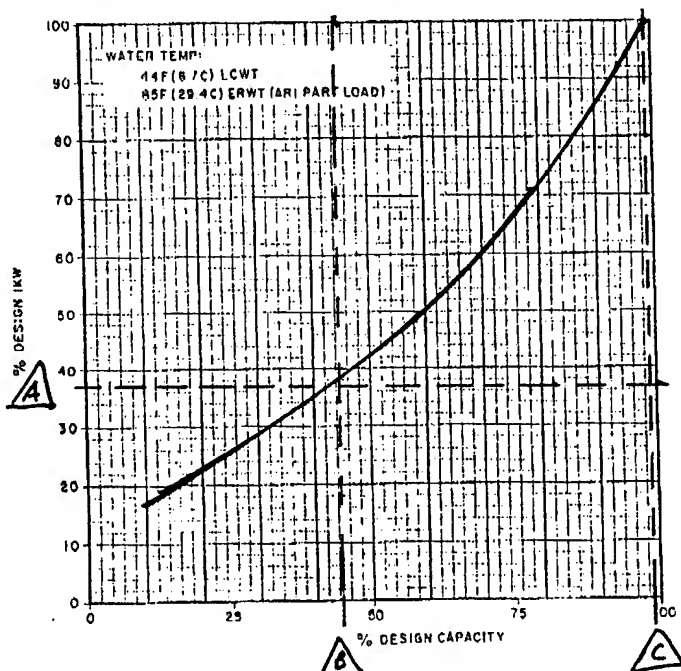
Max. Output MBtu:	<u>3030</u> MBtu
Max. kW Input:	<u>287</u> kW

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 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
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 SCALE \_\_\_\_\_

## CHILLER OUTPUT CALCULATIONS

TYPICAL PART LOAD PERFORMANCE CURVE



Building No.: 4701  
 Chiller No.: 2  
 Chiller Mfg.: CARRIER

**Design Rating:**

Tons: 305 MBtu: 3660  
 Amps: 378 Volts: 460

**Test Reading:**

kW: 105.4 Tons: 144  
 PF: 97

**Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 378 \times 97}{1000} = 292 \text{ kW}$$

$$\text{Tested kW Input} = 105.4 \text{ kW}$$

**From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{105.4}{292} = 36.1 \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{144}{305} = 47 \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):  
99 % X Rated Tons =  $\frac{99 \times 305}{302}$  Tons; or 3623 MBtu

Max. Output MBtu: 3623 MBtu  
 Max. kW Input: 292 kW

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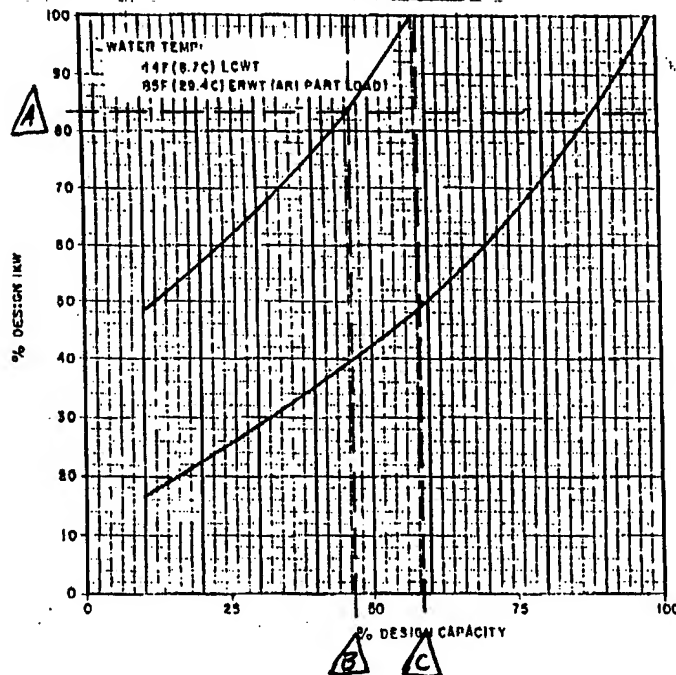
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## **CHILLER OUTPUT CALCULATIONS**

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 5676

Chiller No.: 1

Chiller Mfg.: CARRIER

#### **Design Rating:**

Tons: 170 MBtu: 4500  
Amps: 211 Volts: 460

#### **Test Reading:**

kW: 119.5 Tons: 78  
PF: 86

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 211 \times .86}{1000}$$

$$= \frac{144.6}{1000} \text{ kW}$$

$$\text{Tested kW Input} = \frac{119.5}{1000} \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{119.5}{144.6} = 83 \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{78}{170} = 46 \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (A) :

$$\frac{58}{100} \% \times \text{Rated Tons} = \frac{.58 \times 170}{100} = 99 \text{ Tons; or } 1183 \text{ MBtu}$$

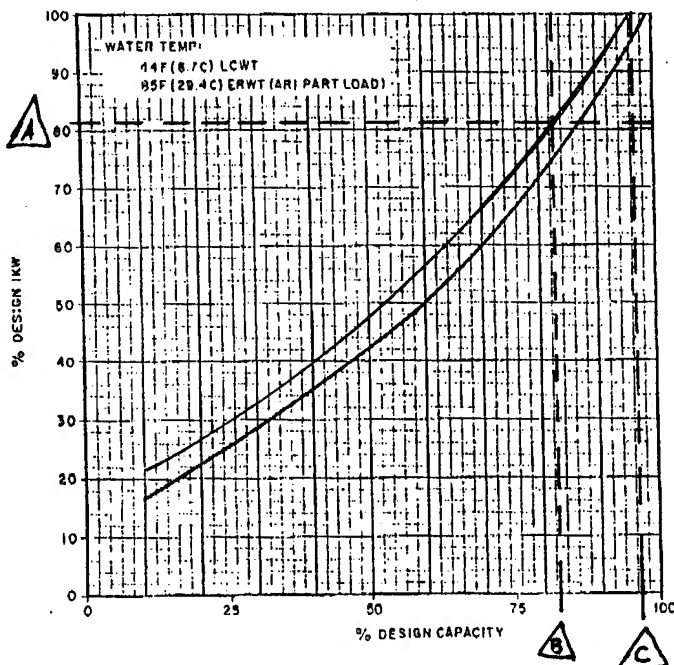
Max. Output MBtu: 1183 MBtu  
Max. kW Input: 144.6 kW

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 SCALE \_\_\_\_\_

## CHILLER OUTPUT CALCULATIONS

### TYPICAL PART LOAD PERFORMANCE CURVE



Building No.: 5678  
 Chiller No.: 1  
 Chiller Mfg.: TRANE

#### Design Rating:

Tons: 190 MBtu: 2280  
 Amps: 195 Volts: 460

#### Test Reading:

kW: 106 Tons: 156  
 PF: 83.5

#### Calculations:

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 195 \times 83.5}{1000}$$

$$= \underline{129.7} \text{ kW}$$

$$\text{Tested kW Input} = \underline{106} \text{ kW}$$

#### From Graph:

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{106}{129.7} = \underline{81.7} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{156}{190} = \underline{82.1} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):  
96 % X Rated Tons =  $\frac{.96 \times 190}{182}$  Tons; or 2188 MBtu

Max. Output MBtu: 2188 MBtu  
 Max. kW Input: 129.7 kW

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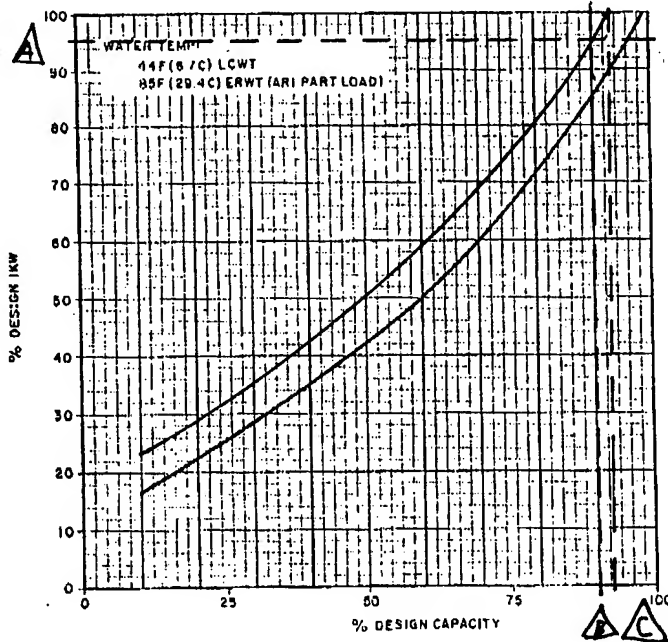
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SCALE \_\_\_\_\_

**CHILLER OUTPUT CALCULATIONS****TYPICAL PART LOAD PERFORMANCE CURVE**Building No.: 5900Chiller No.: 1Chiller Mfg.: CARRIER**Design Rating:**Tons: 400Amps: 476MBtu: 4800Volts: 460**Test Reading:**kW: 324PF: 89.5Tons: 359.7**Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 476 \times .895}{1000}$$

$$= \underline{339.4} \text{ kW}$$

$$\text{Tested kW Input} = \underline{324} \text{ kW}$$

**From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{324}{339.4} = \underline{95.5} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{359.7}{400} = \underline{90} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):

$$\underline{92.5} \% \times \text{Rated Tons} = \underline{.925 \times 400}$$

$$= \underline{370} \text{ Tons; or } \underline{4440} \text{ MBtu}$$

**Max. Output MBtu:** 4440 MBtu**Max. kW Input:** 339.4 kW

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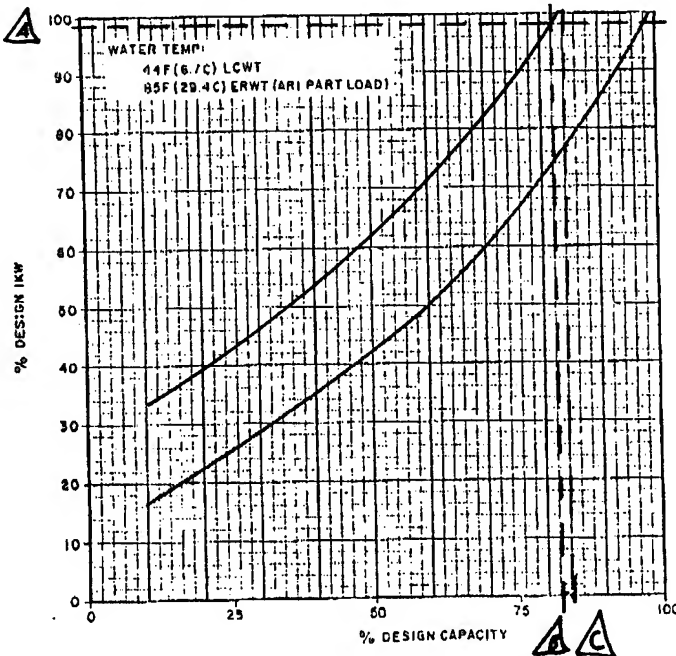
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CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

## **CHILLER OUTPUT CALCULATIONS**

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 5900  
Chiller No.: 2  
Chiller Mfg.: WESTINGHOUSE

#### **Design Rating:**

Tons: 400 MBtu: 4800  
Amps: 438 Volts: 460

#### **Test Reading:**

kW: 309 Tons: 327.7  
PF: 90.6

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 438 \times 90.6}{1000}$$

$$= \underline{316.2} \text{ kW}$$

$$\text{Tested kW Input} = \underline{309} \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{309}{316.2} = \underline{97.7} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{327.7}{400} = \underline{82} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (A):  
84 % X Rated Tons = .84 x 400  
= 336 Tons; or 4032 MBtu

Max. Output MBtu: 4032 MBtu  
Max. kW Input: 316.2 kW

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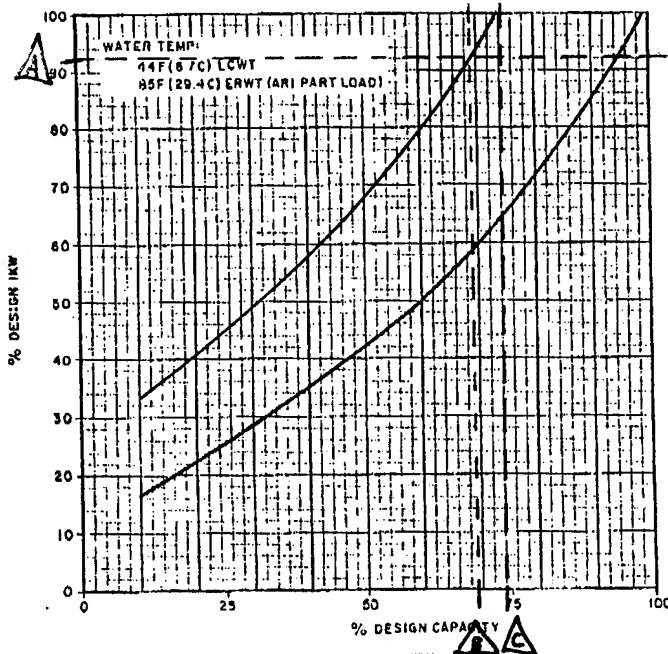
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**CHILLER OUTPUT CALCULATIONS****TYPICAL PART LOAD PERFORMANCE CURVE**Building No.: 5900Chiller No.: 3Chiller Mfg.: CARRIER**Design Rating:**Tons: 400 MBtu: 4800  
Amps: 346 Volts: 480**Test Reading:**kW: 230.8 Tons: 277.84  
PF: 87.3**Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 480 \times 346 \times 87.3\%}{1000}$$

$$= \underline{251.13} \text{ kW}$$

$$\text{Tested kW Input} = \underline{230.8} \text{ kW}$$

**From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{230.8}{251.13} = \underline{92} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{277.84}{400} = \underline{69.5} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):

$$\underline{74} \% \times \text{Rated Tons} = \underline{.74 \times 400}$$

$$= \underline{296} \text{ Tons; or } \underline{3552} \text{ MBtu}$$

**Max. Output MBtu:** 3552 MBtu**Max. kW Input:** 251.13 kW

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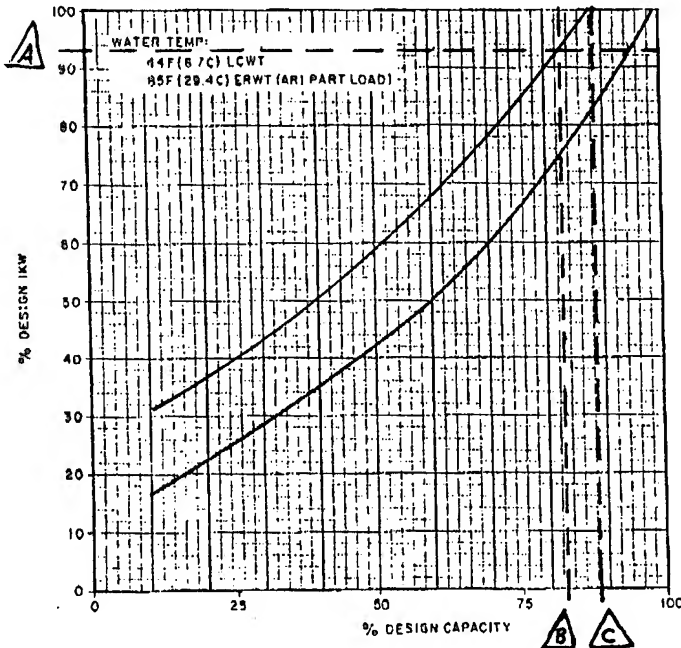
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SCALE \_\_\_\_\_

## **CHILLER OUTPUT CALCULATIONS**

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 5900  
Chiller No.: 4  
Chiller Mfg.: MCQUAY

#### **Design Rating:**

Tons: 450 MBtu: 4800  
Amps: 501 Volts: 480

#### **Test Reading:**

kW: 344.7 Tons: 374  
PF: 89

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 480 \times 501 \times .89}{1000} = 370.7 \text{ kW}$$

$$\text{Tested kW Input} = 344.7 \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{344.7}{370.7} = 93 \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{374}{450} = 83 \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):  
88 % X Rated Tons = .88 X 450  
= 396 Tons; or 4752 MBtu

Max. Output MBtu: 4752 MBtu  
Max. kW Input: 370.7 kW

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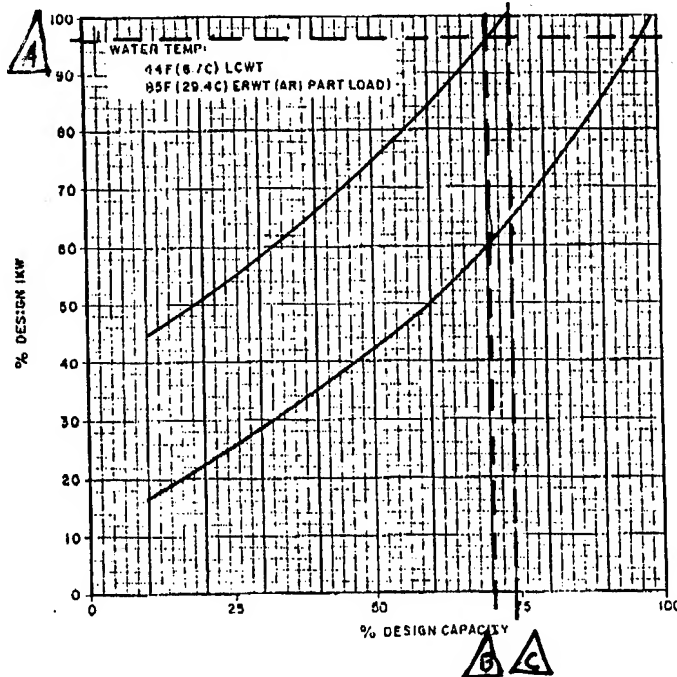
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SCALE \_\_\_\_\_

**CHILLER OUTPUT CALCULATIONS****TYPICAL PART LOAD PERFORMANCE CURVE**Building No.: 5900Chiller No.: 5Chiller Mfg.: CARRIER**Design Rating:**Tons: 400 MBtu: 4800  
Amps: 390 Volts: 460**Test Reading:**kW: 238 Tons: 281  
PF: 80**Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 390 \times .8}{1000}$$

$$= \underline{248.6} \text{ kW}$$

$$\text{Tested kW Input} = \underline{238} \text{ kW}$$

**From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{238}{248.6} = \underline{96} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{281}{400} = \underline{70} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (A):

$$\underline{73} \% \times \text{Rated Tons} = \underline{.73 \times 400}$$

$$= \underline{292} \text{ Tons; or } \underline{3504} \text{ MBtu}$$

Max. Output MBtu:	<u>3504</u>	MBtu
Max. kW Input:	<u>248.6</u>	kW

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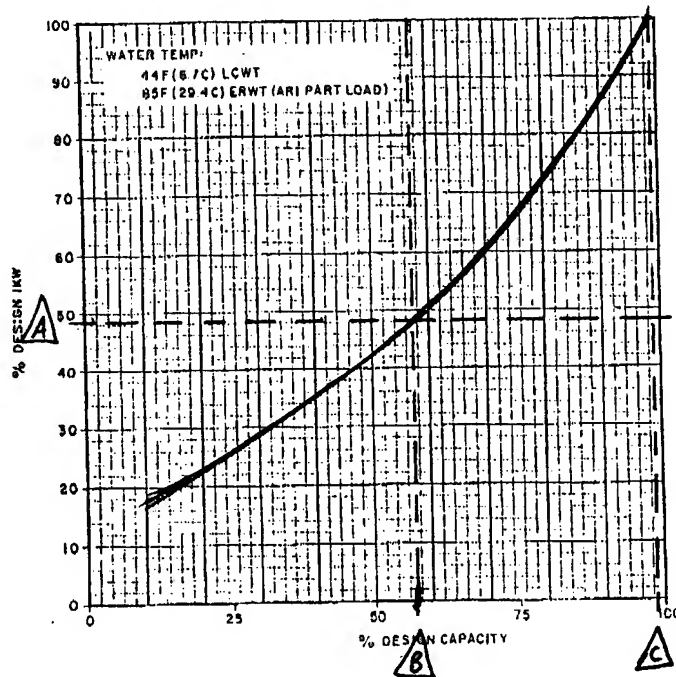
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**CHILLER OUTPUT CALCULATIONS****TYPICAL PART LOAD PERFORMANCE CURVE**
 Building No.: 6003  
 Chiller No.: 2  
 Chiller Mfg.: TRANE
**Design Rating:**
 Tons: 450 MBtu: 5400  
 Amps: 445 Volts: 460
**Test Reading:**
 kW: 136 Tons: 256.5  
 PF: 80
**Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 445 \times .8}{1000}$$

$$= \underline{284} \text{ kW}$$

$$\text{Tested kW Input} = \underline{136} \text{ kW}$$

**From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{136}{284} = \underline{48} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{256.5}{450} = \underline{57} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C):

$$\underline{99} \% \times \text{Rated Tons} = \frac{.99 \times 450}{.80} = \underline{5346} \text{ MBtu}$$

Max. Output MBtu:	<u>5346</u> MBtu
Max. kW Input:	<u>284</u> kW

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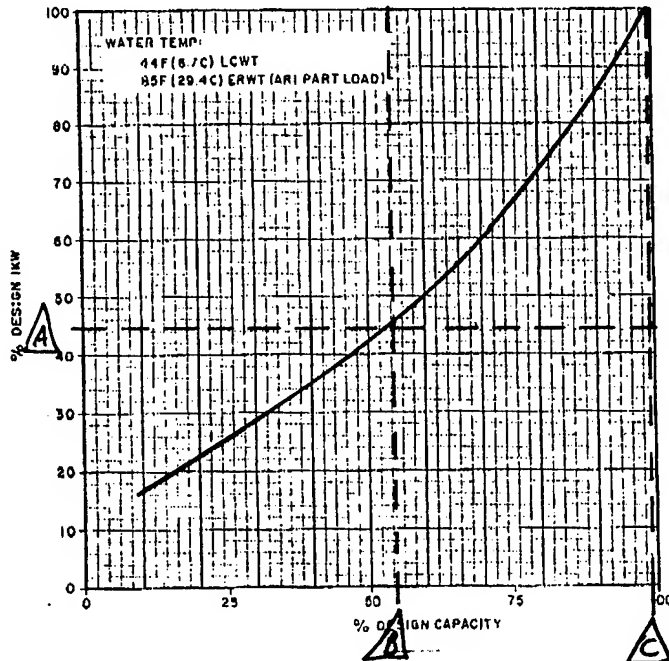
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SCALE \_\_\_\_\_

## **CHILLER OUTPUT CALCULATIONS**

### **TYPICAL PART LOAD PERFORMANCE CURVE**



Building No.: 6003

Chiller No.: 3

Chiller Mfg.: TRANE

#### **Design Rating:**

Tons: 450 MBtu: 5400  
Amps: 445 Volts: 460

#### **Test Reading:**

kW: 125 Tons: 247.5  
PF: 80

#### **Calculations:**

$$\text{Rated kW Input} = \frac{\sqrt{3} \times \text{Volt} \times \text{Rated Amps} \times \text{PF}}{1000} = \frac{\sqrt{3} \times 460 \times 445 \times .8}{1000}$$

$$= \underline{283.6} \text{ kW}$$

$$\text{Tested kW Input} = \underline{125} \text{ kW}$$

#### **From Graph:**

$$\% \text{ Design kW (A)} = \frac{\text{Tested kW Input}}{\text{Rated kW Input}} = \frac{125}{283.6} = \underline{44.1} \%$$

$$\% \text{ Design Capacity (B)} = \frac{\text{Tested Tons}}{\text{Rated Tons}} = \frac{247.5}{450} = \underline{55} \%$$

The part load performance curve is shifted to meet testing conditions, the maximum chiller capacity is (C) :

$$\underline{99} \% \times \text{Rated Tons} = \underline{.99 \times 450} = \underline{445} \text{ Tons; or } \underline{5346} \text{ MBtu}$$

**Max. Output MBtu:** 5346 MBtu  
**Max. kW Input:** 283.6 kW

## **APPENDIX C.2**

### **BOILERS EFFICIENCY CALCULATIONS**

**BOILER COMBUSTION TESTED EFFICIENCY AND CAPACITY**

# BOILER TESTED CAPACITY

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	RATED BOILER INPUT MMBTU/H	LOW FIRE			50% FIRE				
							O2 (%)	CO ppm/%	STACK TEMP (°F)	BOILER EFF (%)	O2 (%)	CO ppm/%	STACK TEMP (°F)	BOILER EFF (%)
5900	1	HTHW	INTERNATIONAL	10.00	6.94	12.50	6.1	10	558	76.30%	5.9	17	595	75.20%
	2	HTHW	INTERNATIONAL	10.00	7.17	12.50	6.6	15	500	77.50%	1.4	25	590	78.00%
	3	HTHW	HERCULES	9.70	7.61	12.13	10.9	3	303	80.70%	5.2	11	400	81.20%
	4	HTHW	HERCULES	9.70	7.58	12.13	12.6	2.95%	231	82.40%	6.4	0.8%	400	80.50%
	5	HTHW	INTERNATIONAL	8.00	6.22	10.00	9.5	55	350	80.30%	8.2	24	410	79.10%
	6	HTHW	INTERNATIONAL	11.20	8.88	14.00	8.4	0	371	80.00%	8	0	360	80.70%
6003	1	STEAM-12	KEWANEE	11.72	9.41	14.65	15.2	0	271	77.20%	7.1	0	322	82.40%
	2	STEAM-12	YORK SHIPLEY	11.72	9.12	14.65	10.4	47	250	82.90%	13	575	263	80.60%
	3	STEAM-12	KEWANEE	11.72	9.37	14.65	14.2	293	240	80.40%	8.6	21	295	82.60%
730	1	STEAM-12	KEWANEE	7.75	6.16	9.69	4	0	185	86.00%	SOOTING PROBLEM, CANNOT TESTED			
	2	STEAM-12	KEWANEE	7.75	6.16	9.69	4	0	192	86.00%	3	0	295	81.50%
	3	STEAM-12	KEWANEE	7.75	6.18	9.69	0.3	0	265	85.60%	5.5	0.35%	345	82.40%
	4	STEAM-12	KEWANEE	2.66	2.11	3.32	12.5	0	222	85.00%				
2812	1	STEAM-12	FEDERAL BOILER CO	1.80	1.40	2.25								
	2	HW	THERMO-PAK BOILER INC.	3.95	2.77	4.94	13.3	0	429	72.00%				
	3	HW	THERMO-PAK BOILER INC.	3.95	2.86	4.94	14.3	0	375	72.40%				
5676	1	HW	AMERICAN STANDARD	2.44	1.80	3.05	15	0	308	74.00%				
	2	HW	AMERICAN STANDARD	2.44	1.71	3.05	11.8	0	453	72.90%				
5678	1	HW	BRUNHAM	2.27	1.50	2.84	17	0.132%	310	74.10%				
	2	HW	BRUNHAM	2.27	1.63	2.84	15.5	0.132%	286	76.60%				
914	1	STEAM-12	BRUNHAM	1.61	1.29	2.01	7.3	9	359	80.90%				
	2	HW	RAY - PAK	1.61	1.22	2.01								
	3	HW	AMERICAN STANDARD	1.92	1.47	2.40								
	4	HW	AMERICAN STANDARD	1.92	1.40	2.40								
4701	1	STEAM-100	BIRCHFIELD	11.00	8.43	13.75	5.2	20	434	80.30%	4.2	30	475	78.90%
	2	STEAM-100	BIRCHFIELD	11.00	0.00	13.75								
	3	STEAM-100	BIRCHFIELD	11.00	8.43	13.75	8.3	19	418	78.70%	3.9	37	457	79.50%

[BOILERS.WK3]

# BOILER TESTED CAPACITY

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	RATED BOILER INPUT MMBTU/H	75% FIRE			100% FIRE (HIGH FIRE)				
							O2 (%)	CO ppm/%	STACK TEMP (°F)	BOILER EFF (%)	O2 (%)	CO ppm/%	STACK TEMP (°F)	BOILER EFF (%)
5900	1	HTHW	INTERNATIONAL	10.00	6.94	12.50	5.6	14	660	73.70%	7	14	702	70.90%
	2	HTHW	INTERNATIONAL	10.00	7.17	12.50					5	42	690	73.20%
	3	HTHW	HERCULES	9.70	7.61	12.13	4.6	17	414	81.00%	5.5	25	434	80.00%
	4	HTHW	HERCULES	9.70	7.58	12.13	4.7	0.2%	418	81.00%	5.9	10%	440	79.60%
	5	HTHW	INTERNATIONAL	8.00	6.22	10.00	6.9	16	440	79.00%	5.6	17	465	79.20%
	6	HTHW	INTERNATIONAL	11.20	8.88	14.00	6.9	0	389	80.60%	5.4	0	402	80.80%
6003	1	STEAM-12	KEWANEE	11.72	9.41	14.65	6.4	0	335	82.30%	6.6	0	337	82.30%
	2	STEAM-12	YORK SHIPLEY	11.72	9.12	14.65	12.7	280	290	80.00%	11.9	200	303	79.80%
	3	STEAM-12	KEWANEE	11.72	9.37	14.65	10	21	310	81.90%				81.90%
730	1	STEAM-12	KEWANEE	7.75	6.16	9.69								
	2	STEAM-12	KEWANEE	7.75	6.16	9.69	0.4	1.5%	416	82.40%	2.7	0.2%	421	81.40%
	3	STEAM-12	KEWANEE	7.75	6.18	9.69	5.6	0.2%	358	82.00%	5.8	0.12%	362	81.70%
	4	STEAM-12	KEWANEE	2.66	2.11	3.32					6.3	0	371	81.50%
2812	1	STEAM-12	FEDERAL BOILER CO	1.80	1.40	2.25					8.7	0	380	79.70%
	2	HW	THERMO-PAK BOILER INC.	3.95	2.77	4.94				13.1	0	429	71.50%	
	3	HW	THERMO-PAK BOILER INC.	3.95	2.86	4.94				10.8	0	472	74.00%	
5676	1	HW	AMERICAN STANDARD	2.44	1.80	3.05					4.6	9.2%	607	75.10%
	2	HW	AMERICAN STANDARD	2.44	1.71	3.05				5	0.02	740	71.40%	
5678	1	HW	BRUNHAM	2.27	1.50	2.84					15.4	0.232%	430	67.50%
	2	HW	BRUNHAM	2.27	1.63	2.84				12	760	454	73.30%	
914	1	STEAM-12	BRUNHAM	1.61	1.29	2.01					3.9	4	387	82.00%
	2	HW	RAY-PAK	1.61	1.22	2.01				8.4	14	454	77.40%	
	3	HW	AMERICAN STANDARD	1.92	1.47	2.40				5.9	26	500	77.90%	
	4	HW	AMERICAN STANDARD	1.92	1.40	2.40				11.1	0	460	74.40%	
4701	1	STEAM-100	BIRCHFIELD	11.00	8.43	13.75	4.9	28	481	78.90%	4.7	31	486	79.20%
	2	STEAM-100	BIRCHFIELD	11.00	0.00	13.75								
	3	STEAM-100	BIRCHFIELD	11.00	8.43	13.75	4.8	37	470	79.50%	5.2	35	474	79.20%

[BOILERS WK3]

## BOILER STANDBY LOSS CALCULATION

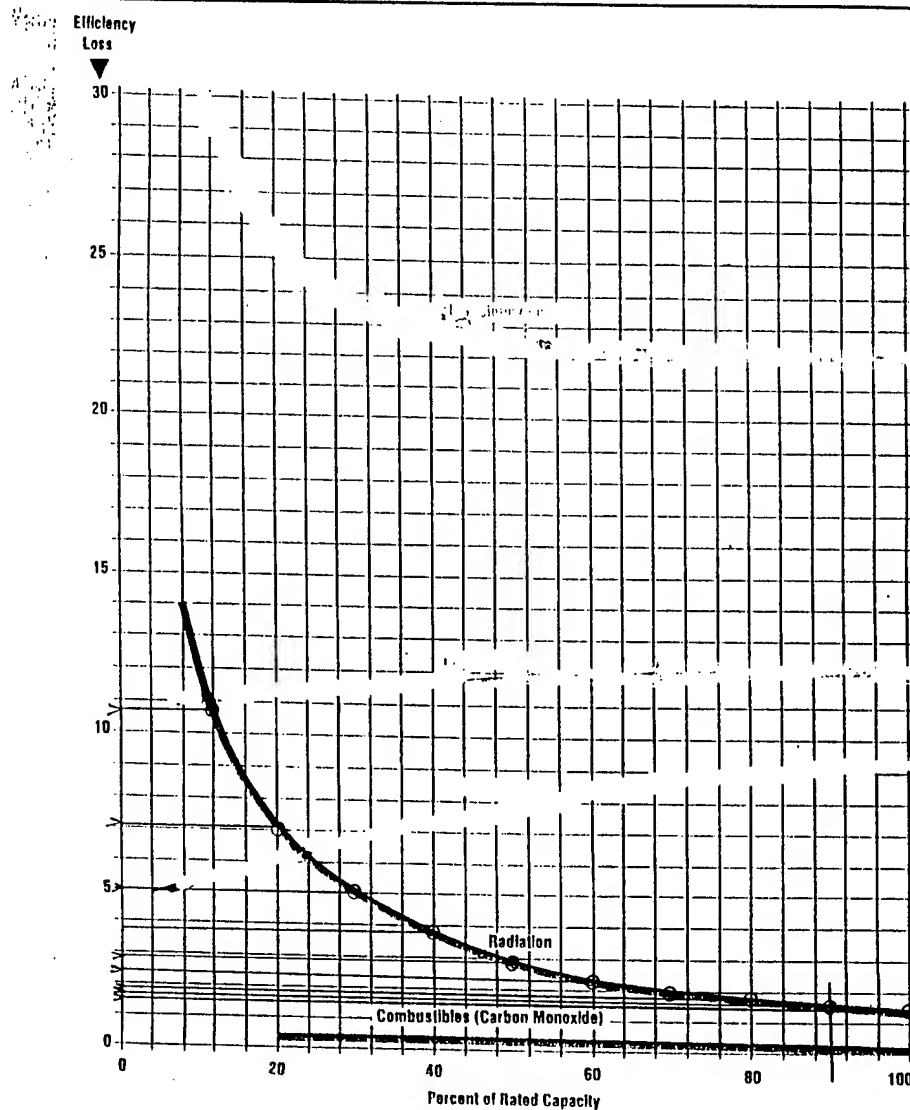


Fig. 42 Effect of Boiler Capacity on Various Losses — FROM "IMPROVING BOILER EFFICIENCY", K.S. UNN.

### BOILER RADIATION (STANDBY) LOSSES

PERCENT OF CAPACITY (%)	EFFICIENCY LOSS (%)
10	10.7
20	7.1
30	5.0
40	3.8
50	2.9
60	2.4
70	1.9
80	1.65
90	1.55
100	1.5

## BOILER BLOWDOWN LOSS CALCULATION

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SCALE \_\_\_\_\_

Percent of Blowdown

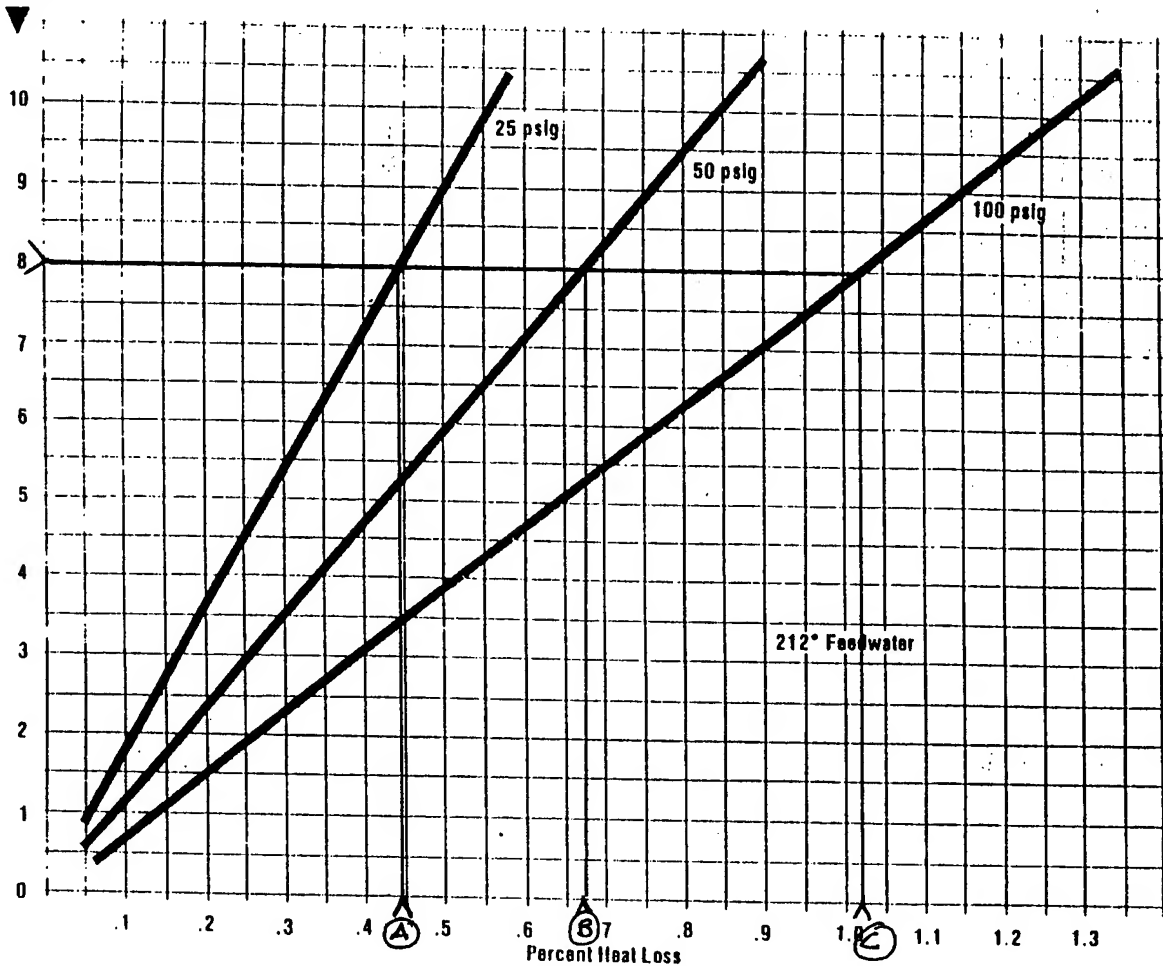


Fig. 37 Effect of Boiler Pressure and % Blowdown on Blowdown Heat Loss

BASED ON 8% BLOWDOWN

- Ⓐ 25 PSIG — .44% HEAT LOSS
- Ⓑ 50 PSIG — .67% " "
- Ⓒ 100 PSIG — 1.02% " "

SOURCE: "IMPROVING BOILER EFFICIENCY", KANSAS STATE UNIVERSITY

**BOILER COMBUSTION TESTED EFFICIENCY AND CAPACITY  
INCLUDED STANDBY AND BLOWDOWN LOSSES**

# BOILER CAPACITY AND TEST RESULTS

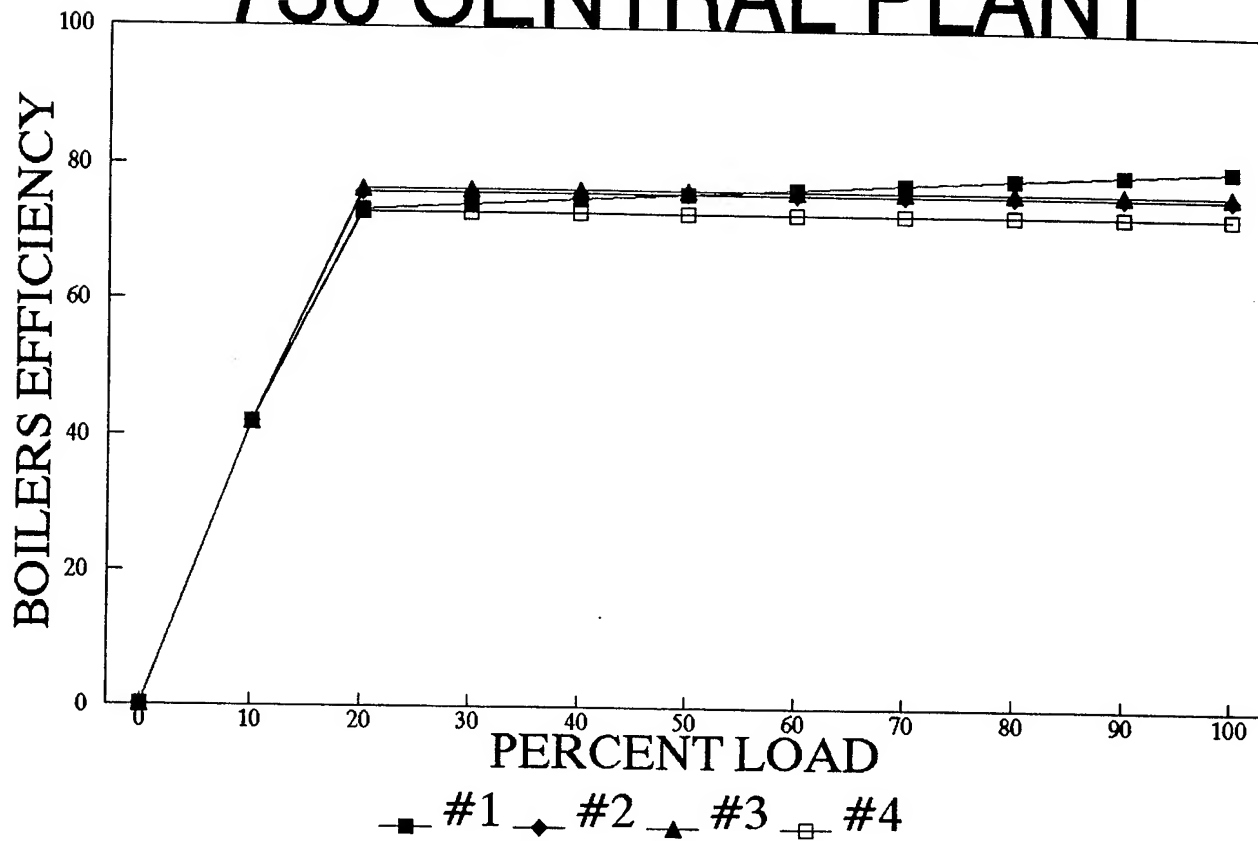
BLOWDOWN LOSSES	25 PSIG	0.44%
	50 PSIG	0.67%
	100 PSIG	1.02%

[BOILERS WKS]

STANDBY LOSSES														7.10%	2.90%	1.90%	1.50%
BLDG. NUMB	NUMBER OF BOILER	BOILER TYPE	BOILER MANUFACTURER	BOILER OUTPUT MBTU/H	BOILER OUTPUT MBTU/H	LOWFIRE TESTED	LOWFIRE W/LOSSES	50% FIRE TESTED	50% FIRE W/LOSSES	75% FIRE TESTED	75% FIRE W/LOSSES	HIGHFIRE TESTED	HIGHFIRE W/LOSSES				
5900	1	HTHW	INTERNATIONAL	6.94	12.50	76.30%	69.20	75.20%	72.30	73.70%	71.80	70.90%	69.40				
	2	HTHW	INTERNATIONAL	7.17	12.50	77.50%	70.40	78.00%	75.10			73.20%	71.70				
	3	HTHW	HERCULES	7.61	12.13	80.70%	73.60	81.20%	78.30	81.00%	79.10	80.00%	78.50				
	4	HTHW	HERCULES	7.58	12.13	82.40%	75.30	80.50%	77.60	81.00%	79.10	79.60%	78.10				
	5	HTHW	INTERNATIONAL	6.22	10.00	80.30%	73.20	79.10%	76.20	79.00%	77.10	79.20%	77.70				
	6	HTHW	INTERNATIONAL	8.88	14.00	80.00%	72.90	80.70%	77.80	80.60%	78.70	80.80%	79.30				
6003	1	STEAM-12	KEWANEE	9.41	14.65	77.20%	69.66	82.40%	79.06	82.30%	79.96	82.30%	80.36				
	2	STEAM-12	YORK SHIPLEY	9.12	14.65	82.90%	75.36	80.60%	77.26	80.00%	77.66	79.80%	77.86				
	3	STEAM-12	KEWANEE	9.37	14.65	80.40%	72.86	82.60%	79.26	81.90%	79.56	81.90%	79.96				
730	1	STEAM-12	KEWANEE	6.16	9.69	86.00%	78.46										
	2	STEAM-12	KEWANEE	6.16	9.69	86.00%	78.46	81.50%	78.16	82.40%	80.06	81.40%	79.46				
	3	STEAM-12	KEWANEE	6.18	9.69	85.60%	78.06	82.40%	79.06	82.00%	79.66	81.70%	79.76				
	4	STEAM-12	KEWANEE	2.11	3.32	85.00%	77.46					81.50%	79.56				
2812	1	STEAM-12	FEDERAL BOILER CO	1.40	2.25												
	2	HW	THERMO-PAK BOILER INC.	2.77	4.94	72.00%	64.90					71.50%	70.00				
	3	HW	THERMO-PAK BOILER INC.	2.86	4.94	72.40%	65.30					74.00%	72.50				
5676	1	HW	AMERICAN STANDARD	1.80	3.05	74.00%	66.90					75.10%	73.60				
	2	HW	AMERICAN STANDARD	1.71	3.05	72.90%	65.80					71.40%	69.90				
5678	1	HW	BRUNHAM	1.50	2.84	74.10%	67.00					67.50%	66.00				
	2	HW	BRUNHAM	1.63	2.84	76.60%	69.50					73.30%	71.80				
914	1	STEAM-12	BRUNHAM	1.29	2.01	80.90%	73.36					82.00%	80.06				
	2	HW	RAY-PAK	1.22	2.01							77.40%	75.90				
	3	HW	AMERICAN STANDARD	1.47	2.40							77.90%	76.40				
	4	HW	AMERICAN STANDARD	1.40	2.40							74.40%	72.90				
4701	1	STEAM-100	BIRCHFIELD	8.43	13.75	80.30%	72.18	78.90%	74.98	78.90%	75.98	79.20%	76.68				
	2	STEAM-100	BIRCHFIELD	0.00	13.75												
	3	STEAM-100	BIRCHFIELD	8.43	13.75	78.70%	70.58	79.50%	75.58	79.50%	76.58	79.20%	76.68				

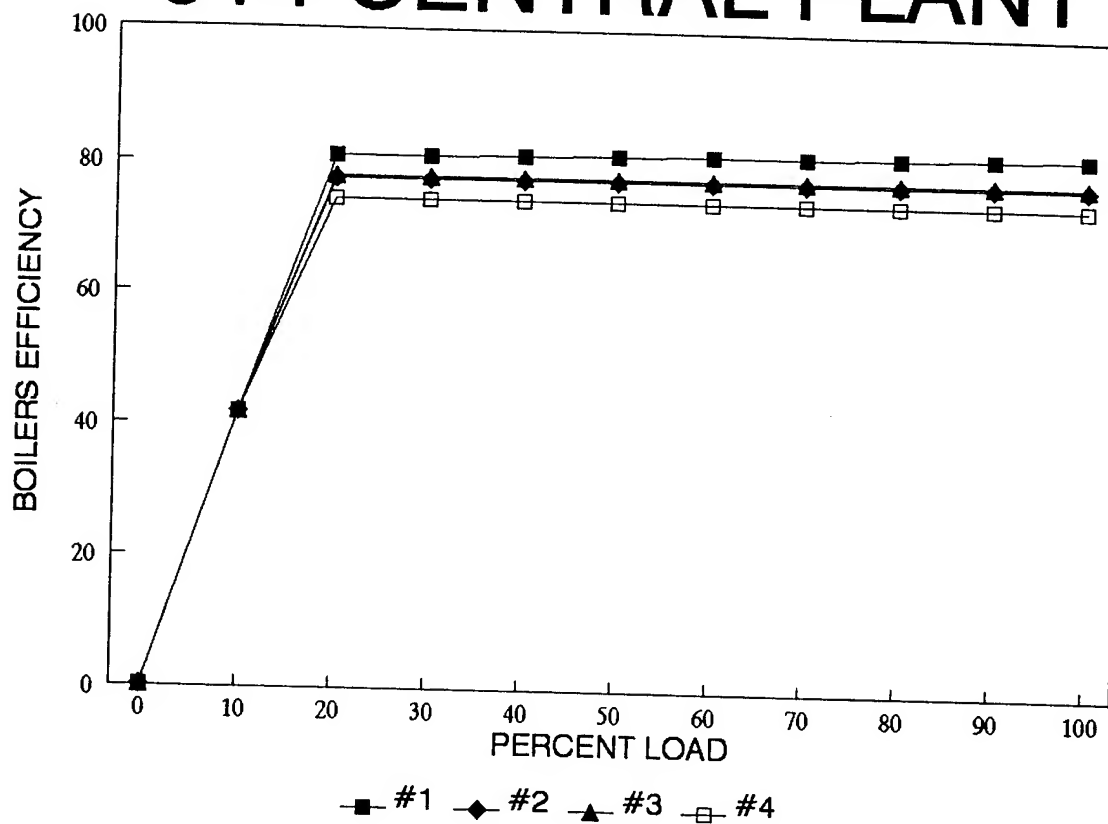
BLDG. NUMBER	NUMBER OF BOILER	BOILER MANUFACTURERER	BOILER MODEL NUMBER	PERCENT LOAD	BOILERS TESTING EFF.	PERCENT MAX. ENERGY INPUT
730  13-Mar-91 08:28:00 AM	1	KEWANEE	CAT#7L286-KX	0	0.2	0.0
				10	42	0.0
				20	78.5	0.0
				30	52.3	0.0
				40	26.2	0.0
				50	0.0	ERR
				60	0.0	ERR
				70	0.0	ERR
				80	0.0	ERR
				90	0.0	ERR
				100	0.0	ERR
	2	KEWANEE	CAT#7L286-KX	0	0.2	0.0
				10	42.0	18.9
				20	78.5	20.3
				30	78.4	30.4
				40	78.3	40.6
				50	78.2	50.8
				60	78.4	60.8
				70	80.1	69.5
				80	80.3	79.1
				90	80.6	88.7
				100	79.5	100.0
	3	KEWANEE	CAT#7L286-KX	0	0.2	0.0
				10	42	19.0
				20	78.1	20.4
				30	78.4	30.5
				40	78.7	40.5
				50	79.1	50.4
				60	79.2	60.4
				70	79.7	70.1
				80	79.8	80.0
				90	79.9	89.8
				100	79.8	100.0
	4	KEWANEE	CAT#7L280-KG-	0	0.2	0.0
				10	42	18.9
				20	77.5	20.5
				30	77.7	30.7
				40	78.0	40.8
				50	78.2	50.8
				60	78.5	60.8
				70	78.8	70.7
				80	79.0	80.5
				90	79.3	90.3
				100	79.6	100.0

# 730 CENTRAL PLANT



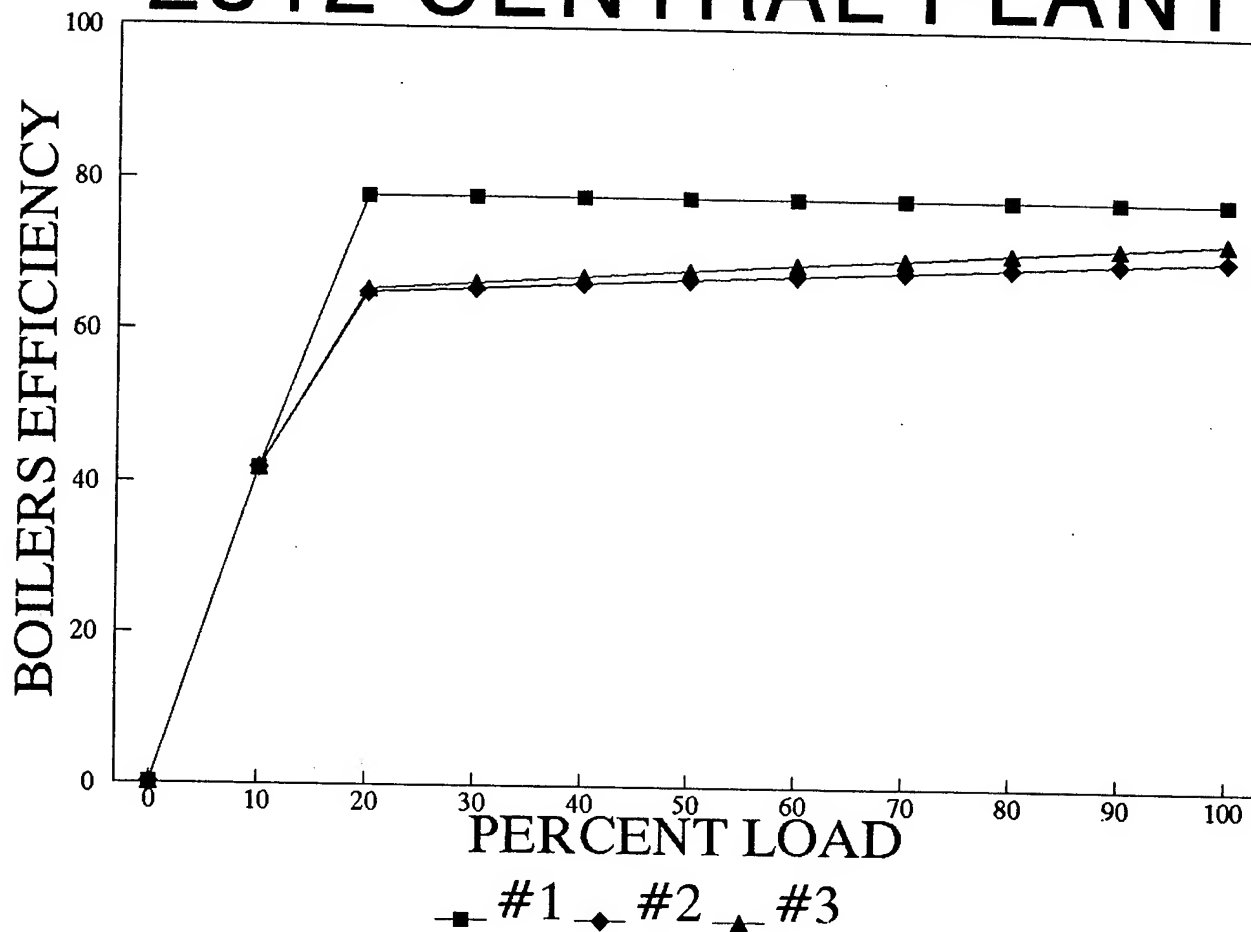
BLDG. NUMBER	NUMBER OF BOILER	BOILER MANUFACTURER	BOILER MODEL NUMBER	PERCENT LOAD	BOILERS TESTING EFF.	PERCENT MAX. ENERGY INPUT
914  13-Mar-91 08:28:00 AM	1	BRUNHAM	PF510	0	0.2	0.0
				10	42	19.1
				20	73.4	21.8
				30	74.2	32.4
				40	75.0	42.7
				50	75.9	52.8
				60	76.7	62.6
				70	77.5	72.3
				80	78.4	81.7
				90	79.2	91.0
				100	80.1	100.0
	2	RAY-PAK	EA 200ITB	0	0.2	0.0
				10	42	18.1
				20	75.9	20.0
				30	75.9	30.0
				40	75.9	40.0
				50	75.9	50.0
				60	75.9	60.0
				70	75.9	70.0
				80	75.9	80.0
				90	75.9	90.0
				100	75.9	100.0
	3	AMERICAN STD	G1015	0	0.2	0.0
				10	42	18.2
				20	76.4	20.0
				30	76.4	30.0
				40	76.4	40.0
				50	76.4	50.0
				60	76.4	60.0
				70	76.4	70.0
				80	76.4	80.0
				90	76.4	90.0
				100	76.4	100.0
	4	AMERICAN STD	G1015	0	0.2	0.0
				10	42	17.4
				20	72.9	20.0
				30	72.9	30.0
				40	72.9	40.0
				50	72.9	50.0
				60	72.9	60.0
				70	72.9	70.0
				80	72.9	80.0
				90	72.9	90.0
				100	72.9	100.0

# 914 CENTRAL PLANT



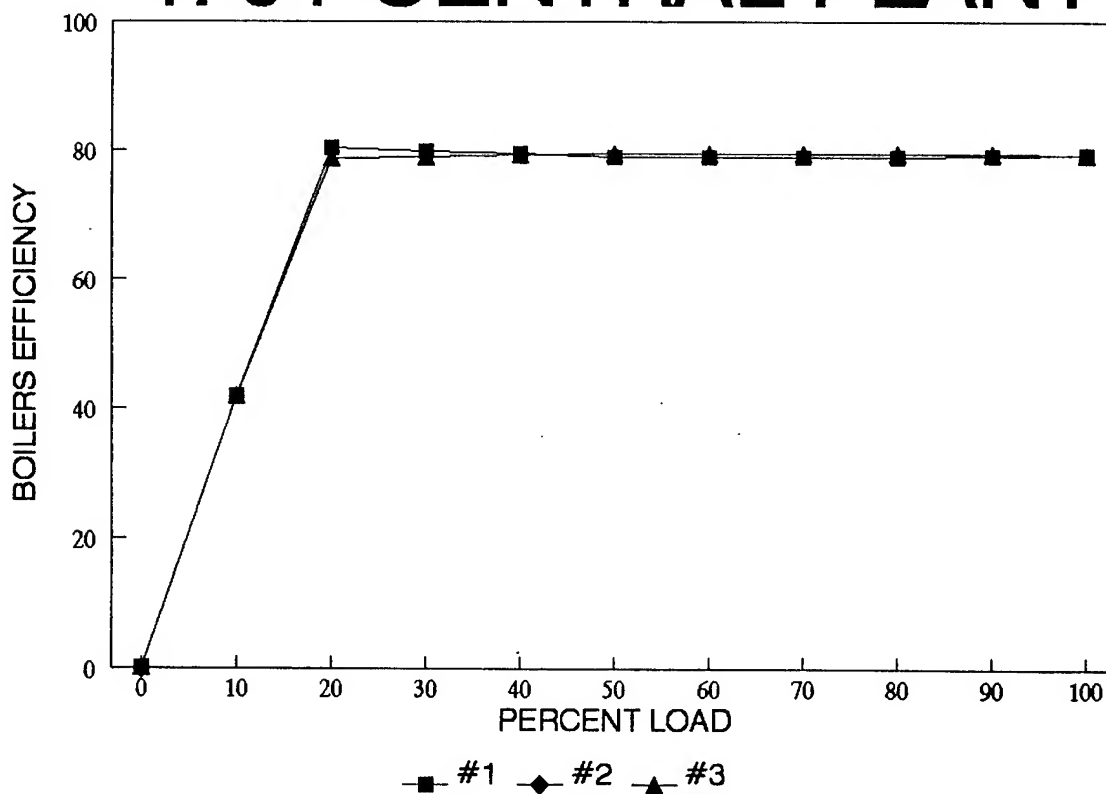
BLDG. NUMBER	NUMBER OF BOILER	BOILER MANUFACTURERER	BOILER MODEL NUMBER	PERCENT LOAD	BOILERS TESTING EFF.	PERCENT MAX. ENERGY INPUT
2812  13-Mar-91 08:28:00 AM	1	FEDERAL BOILER CO	GS 3562	0	0.2	0.0
				10	42	18.5
				20	77.8	20.0
				30	77.8	30.0
				40	77.8	40.0
				50	77.8	50.0
				60	77.8	60.0
				70	77.8	70.0
				80	77.8	80.0
				90	77.8	90.0
				100	77.8	100.0
	2	THERMO-PAK BOILER	GW 5500X	0	0.2	0.0
				10	42	16.7
				20	64.9	21.6
				30	65.5	32.0
				40	66.2	42.3
				50	66.8	52.4
				60	67.5	62.3
				70	68.1	72.0
				80	68.7	81.5
				90	69.4	90.8
				100	70.0	100.0
	4	KEWANEE	CAT#7L280-KG-	0	0.2	0.0
				10	42	17.3
				20	65.3	22.2
				30	66.2	32.9
				40	67.1	43.2
				50	68.0	53.3
				60	68.9	63.1
				70	69.8	72.7
				80	70.7	82.0
				90	71.6	91.1
				100	72.5	100.0

# 2812 CENTRAL PLANT



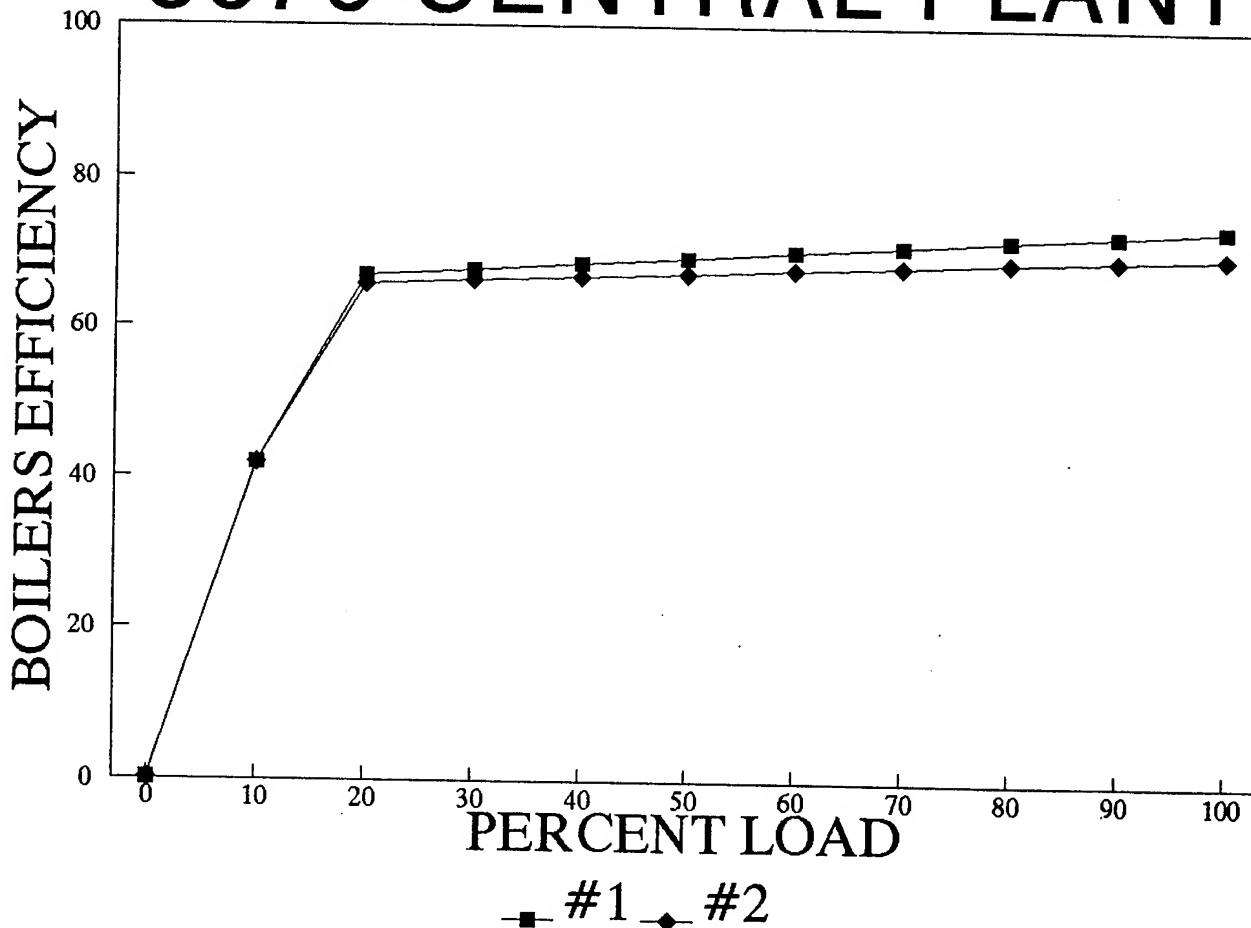
BLDG. NUMBER	NUMBER OF BOILER	BOILER MANUFACTURERER	BOILER MODEL NUMBER	PERCENT LOAD	BOILERS TESTING EFF.	PERCENT MAX. ENERGY INPUT
4701  13-Mar-91 08:28:00 AM	1	BIRCHFIELD	FBH 578	0	0.2	0.0
				10	42	18.3
				20	72.8	21.1
				30	73.5	31.3
				40	74.2	41.3
				50	75.0	51.1
				60	75.3	61.1
				70	76.0	70.6
				80	76.3	80.4
				90	76.7	90.0
				100	76.7	100.0
	2	BIRCHFIELD	FBH 578	0	0.2	0.0
				10	42	0.0
				20	0.0	ERR
				30	0.0	ERR
				40	0.0	ERR
				50	0.0	ERR
				60	0.0	ERR
				70	0.0	ERR
				80	0.0	ERR
				90	0.0	ERR
				100	0.0	ERR
	3	BIRCHFIELD	FBH 578	0	0.2	0.0
				10	42	18.3
				20	71.2	21.6
				30	72.6	31.7
				40	74.1	41.4
				50	75.6	50.7
				60	75.8	60.7
				70	76.6	70.1
				80	76.8	79.9
				90	77.0	89.6
				100	76.7	100.0

## 4701 CENTRAL PLANT



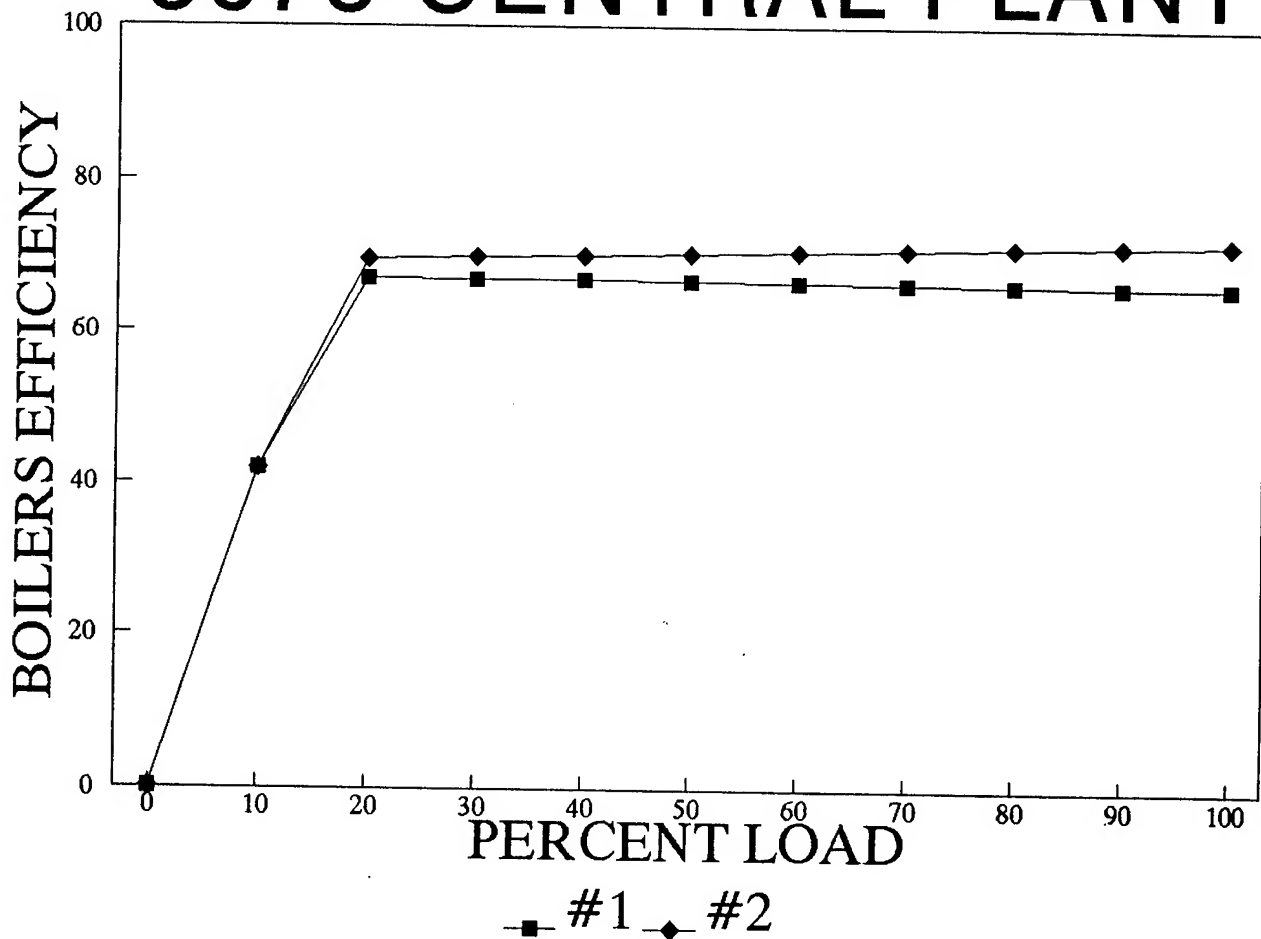
BLDG. NUMBER	NUMBER OF BOILER	BOILER MANUFACTURER	BOILER MODEL NUMBER	PERCENT LOAD	BOILERS TESTING EFF.	PERCENT MAX. ENERGY INPUT
5676  13-Mar-91 08:28:00 AM	1	AMERICAN STANDARD	PF515	0	0.2	0.0
				10	42	17.5
				20	66.9	22.0
				30	67.7	32.6
				40	68.6	42.9
				50	69.4	53.0
				60	70.3	62.9
				70	71.1	72.5
				80	71.9	81.9
				90	72.8	91.0
				100	73.6	100.0
	2	AMERICAN STANDARD	PF515	0	0.2	0.0
				10	42	16.6
				20	65.8	21.2
				30	66.3	31.6
				40	66.8	41.8
				50	67.3	51.9
				60	67.9	61.8
				70	68.4	71.6
				80	68.9	81.2
				90	69.4	90.7
				100	69.9	100.0

## 5676 CENTRAL PLANT



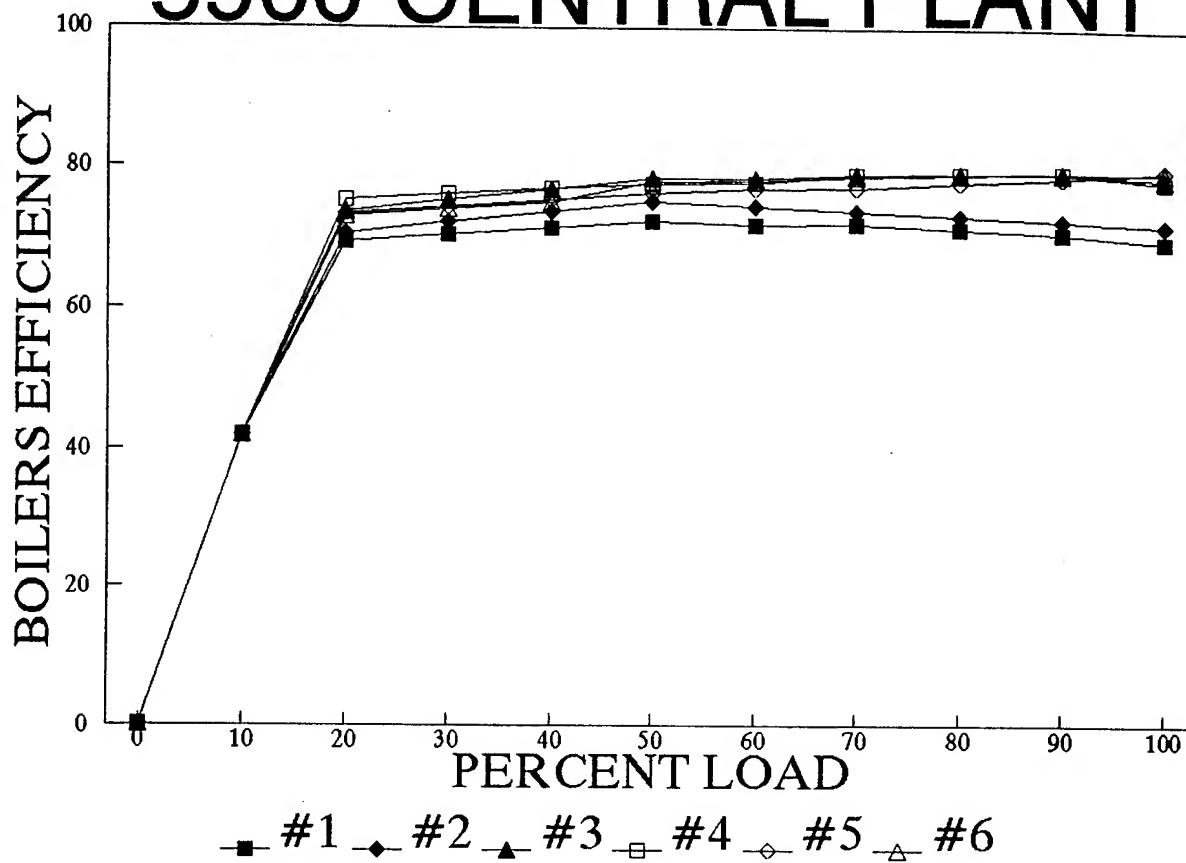
BLDG. NUMBER	NUMBER OF BOILER	BOILER MANUFACTURER	BOILER MODEL NUMBER	PERCENT LOAD	BOILERS TESTING EFF.	PERCENT MAX. ENERGY INPUT
5678  13-Mar-91 08:28:00 AM	1	BRUNHAM	PF514	0	0.2	0.0
				10	42	15.7
				20	67.0	19.7
				30	66.9	29.6
				40	66.8	39.6
				50	66.6	49.5
				60	66.5	59.5
				70	66.4	69.6
				80	66.3	79.7
				90	66.1	89.8
				100	66.0	100.0
	2	BRUNHAM	PF514	0	0.2	0.0
				10	42	17.1
				20	69.5	20.7
				30	69.8	30.9
				40	70.1	41.0
				50	70.4	51.0
				60	70.6	61.0
				70	70.9	70.9
				80	71.2	80.6
				90	71.5	90.4
				100	71.8	100.0

## 5678 CENTRAL PLANT



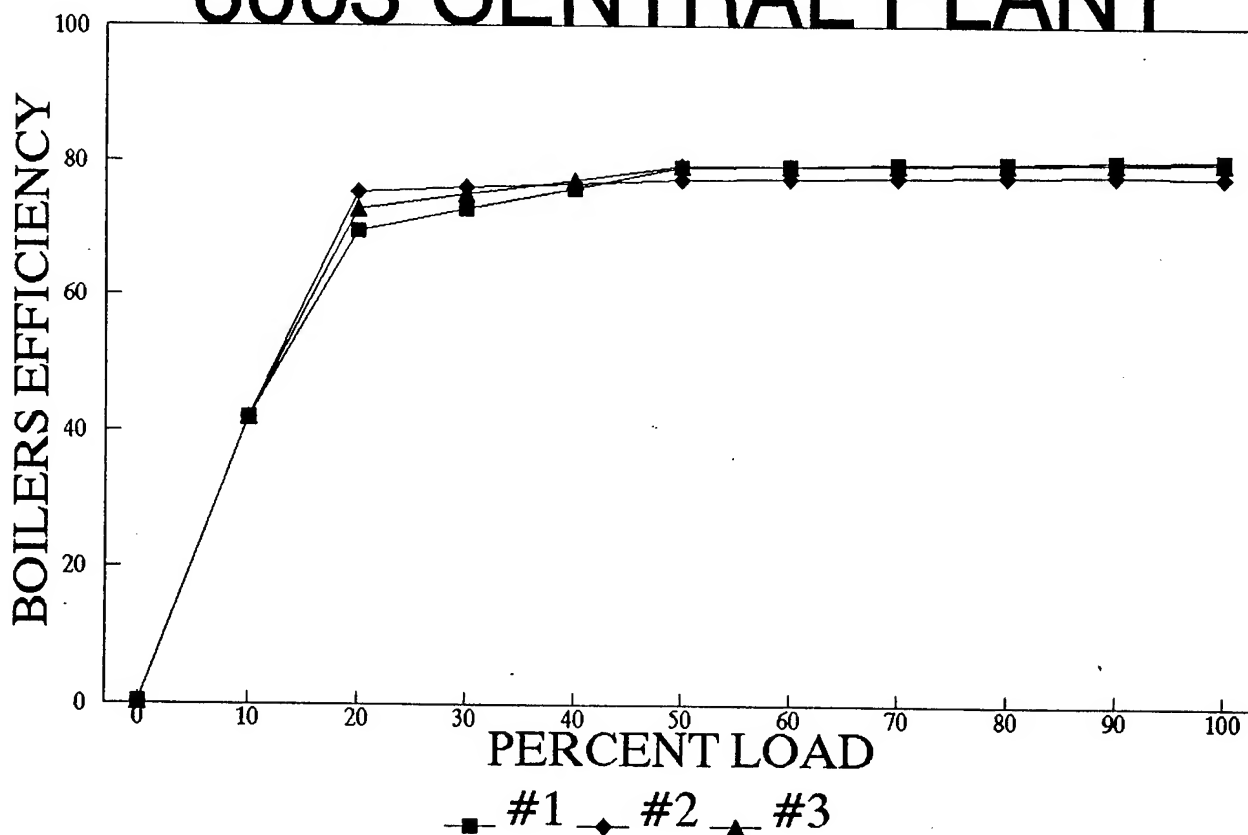
BLDG. NUMBER	NUMBER OF BOILER	BOILER MANUFACTURER	BOILER MODEL NUMBER	PERCENT LOAD	BOILERS TESTING EFF.	PERCENT MAX. ENERGY INPUT
5900  13-Mar-91 08:28:00 AM	1	INTERNATIONAL	D-12	0	0.2	0.0
				10	42	16.5
				20	69.2	20.1
				30	70.2	29.6
				40	71.3	39.0
				50	72.3	48.0
				60	71.7	58.1
				70	71.8	67.7
				80	71.2	78.0
				90	70.6	88.4
				100	69.4	100.0
	2	INTERNATIONAL	D-12	0	0.2	0.0
				10	42.0	17.1
				20	70.4	20.4
				30	72.0	29.9
				40	73.5	39.0
				50	75.1	47.7
				60	74.4	57.8
				70	73.7	68.1
				80	73.1	78.5
				90	72.4	89.2
				100	71.7	100.0
	3	HERCULES	300	0	0.2	0.0
				10	42	18.7
				20	73.6	21.3
				30	75.2	31.3
				40	76.7	40.9
				50	78.3	50.1
				60	78.3	60.1
				70	79.1	69.5
				80	79.1	79.4
				90	79.2	89.2
				100	78.5	100.0
	4	HERCULES	300	0	0.2	0.0
				10	42	18.6
				20	75.3	20.7
				30	76.1	30.8
				40	76.8	40.7
				50	77.6	50.3
				60	77.7	60.3
				70	79.1	69.1
				80	79.2	78.9
				90	79.3	88.6
				100	78.1	100.0
	5	INTERNATIONAL	1035 TH12	0	0.2	0.0
				10	42	19.0
				20	73.2	21.8
				30	74.2	32.2
				40	75.2	42.4
				50	76.2	52.3
				60	76.9	62.2
				70	77.1	72.4
				80	77.8	82.0
				90	78.5	91.4
				100	79.8	100.0
	6	INTERNATIONAL	TJW-C-10	0	0.2	0.0
				10	42	18.9
				20	72.9	21.8
				30	73.9	32.2
				40	74.9	42.4
				50				77.8	51.0
				60				78.1	60.9
				70				78.7	70.5
				80				79.0	80.3
				90				79.3	90.0
				100				79.3	100.0

# 5900 CENTRAL PLANT



BLDG. NUMBER	NUMBER OF BOILER	BOILER MANUFACTURER	BOILER MODEL NUMBER	PERCENT LOAD	BOILERS TESTING EFF.	PERCENT MAX. ENERGY INPUT
6003 13-Mar-91 08:28:00 AM	1	KEWANEE	L39-350-605	0	0.2	0.0
				10	42	19.1
				20	69.7	23.1
				30	72.8	33.1
				40	75.9	42.3
				50	79.1	50.8
				60	79.3	60.8
				70	79.6	70.7
				80	79.8	80.5
				90	80.1	90.3
				100	80.4	100.0
	2	YORK SHIPLEY	SPL-350-N11208	0	0.2	0.0
				10	42.0	18.5
				20	75.4	20.7
				30	76.0	30.7
				40	76.6	40.6
				50	77.3	50.4
				60	77.4	60.4
				70	77.7	70.2
				80	77.8	80.1
				90	77.9	90.0
				100	77.9	100.0
	3	KEWANEE	L36-350-605	0	0.2	0.0
				10	42	19.0
				20	72.9	21.9
				30	75.0	32.0
				40	77.1	41.5
				50	79.3	50.4
				60	79.4	60.4
				70	79.6	70.4
				80	79.7	80.3
				90	79.8	90.1
				100	80.0	100.0

## 6003 CENTRAL PLANT



## BOILER STANDBY LOSS SAVING CALCULATION

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (1%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0		
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	51.82	\$150.74
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.82	\$160.09
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	\$159.27
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0		
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0		
					TOTAL	9.41	0.0941	2160	160.99	\$470.10
6003	1	STEAM-12	KEWANEE	L39-350-605	11.72	9.12	0.0912	0		
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0		
	3	STEAM-12	KEWANEE	L36-350-605	11.72	9.37	0.0937	720	67.45	\$196.96
					TOTAL	6.16	0.0616	720	67.45	\$196.96
730	1	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	0		
	2	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	720	44.34	\$129.47
	3	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANEE	CAT#7L280-KG-06	2.66	2.11	0.0211	0		
					TOTAL	1.40	0.0140	1440	88.84	\$259.43
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3562	1.80	1.40	0.0140	0		
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.77	0.0277	0		
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.82	\$60.21
					TOTAL	1.80	0.0180	720	20.82	\$60.21
5676	1	HW	AMERICAN STANDARD	PF 515	2.44	1.80	0.0180	720	12.93	\$37.76
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
					TOTAL	1.50	0.0150	720	12.93	\$37.76
5678	1	HW	BRUNHAM	PF 514	2.27	1.50	0.0150	720	10.79	\$31.50
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
					TOTAL	1.29	0.0129	720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.61	1.29	0.0129	0		
	2	HW	RAY-PAK	EA 200ITB	1.61	1.22	0.0122	0		
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0		
					TOTAL	8.43	0.0843	720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	0		
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
					TOTAL	8.43	0.0843	720	60.73	\$177.33

[BOILERS.WK3]

**APPENDIX D**

**ECO ANALYSIS**

CENTRAL PLANT 730

D-730-1

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-1  
**SYSTEM MODIFICATION:** ADD INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-1, install instrumentation to facilitate efficient operation of chiller plant. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	525	883,000	20,988	24,002
ECO	396	640,000	20,988	23,172
Savings (Baseline-ECO)	129	243,000	0	829

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 829 MMBtu/Yr X \$4.0141 /MMBtu = \$3,329 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$3,329 + \$0 = \$3,329 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 129 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$2,766 per year  
 Maintenance: = (-) \$320 per year  
**Total: \$2,766 - \$320 = \$2,446 per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTAL PALNT 730 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING SEASONS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	20987.
PEAK DAY GAS CONSUMP., 1000 CU FT	287.
ELECTRICAL CONSUMPTION, KWH	883113.
PEAK KW DEMAND (15 MIN BASIS)	525.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	883113.
ON-PEAK KW DEMAND (15 MIN BASIS)	525.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
BOILER OPERATING HOURS	
BOILER 1	1507
BOILER 2	980
BOILER 3	570
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

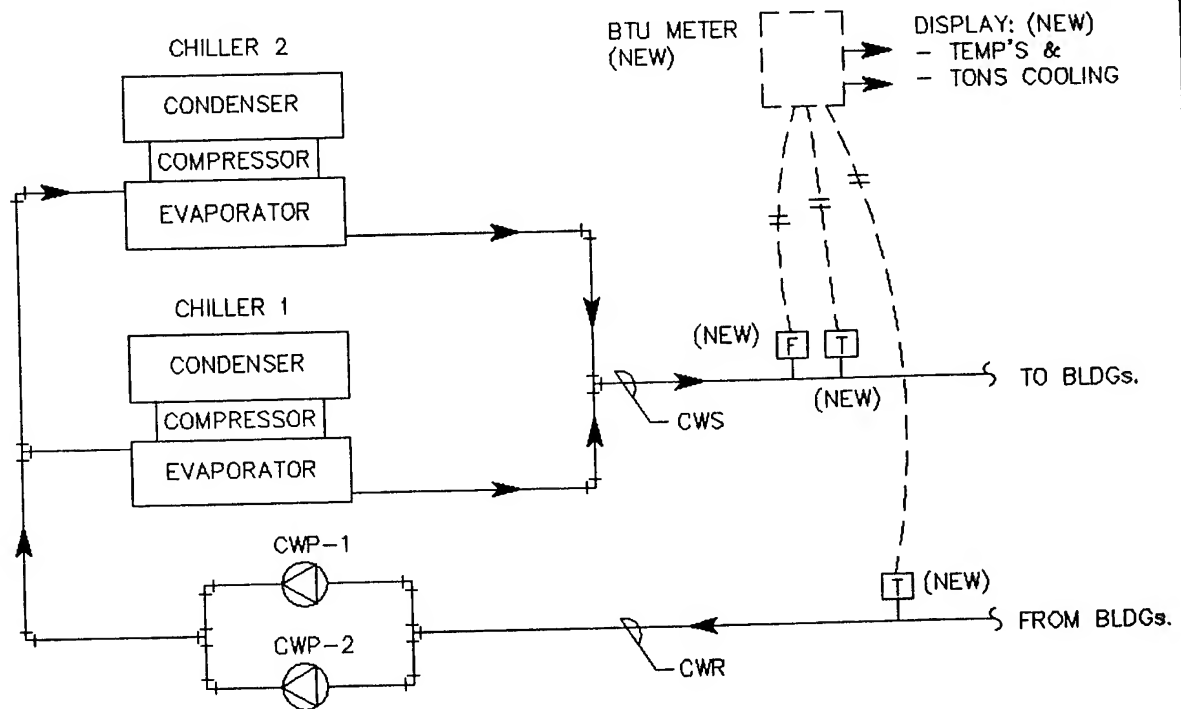
CENTRAL PLANT 730 CHILLER ECO-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HTG &amp; COOLING W/KW PUMP REDUCTION

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	20987.
PEAK DAY GAS CONSUMP., 1000 CU FT	287.
ELECTRICAL CONSUMPTION, KWH	641100.
PEAK KW DEMAND (15 MIN BASIS)	396.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	641100.
ON-PEAK KW DEMAND (15 MIN BASIS)	396.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
BOILER OPERATING HOURS	
BOILER 1	1507
BOILER 2	980
BOILER 3	570
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# ECO-1, INSTRUMENTATION FOR CHILLER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[C-ECO-1.DWG]

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C730ECO

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER INSTRUMENTATION

ANALYSIS DATE: 04-08-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	5327.
B. SIOH	\$	293.
C. DESIGN COST	\$	320.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5346.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5346.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	829.	\$ 3328.	8.78	29216.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		829.	\$ 3328.		\$ 29216.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	2446.
(1) DISCOUNT FACTOR (TABLE A)		
(2) DISCOUNTED SAVING/COST (3A X 3A1)	9.11	\$ 22283.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	22283.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	9641.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=	7.27	
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 5774.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 51499.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 9.63  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 .93

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-2  
**SYSTEM MODIFICATION:** CHILLER OPTIMIZATION, ADD INSTRUMENTATION  
**SYSTEMS TO MODIFY:** CHILLER 1 AND 3

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-2, install instrumentation connected to EMCS for chiller optimization. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	525	883,000	20,988	24,002
ECO	362	545,000	20,988	22,848
Savings (Baseline-ECO)	163	338,000	0	1,154

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 1154 MMBtu/Yr X \$4.0141 /MMBtu = \$4,631 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$4,631 + \$0 = \$4,631 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 163 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$3,495 per year  
 Maintenance: = (-) \$1,077 per year  
 Total: \$3,495 - \$1,077 = \$2,418 per year

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTAL PALNT 730 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING SEASONS

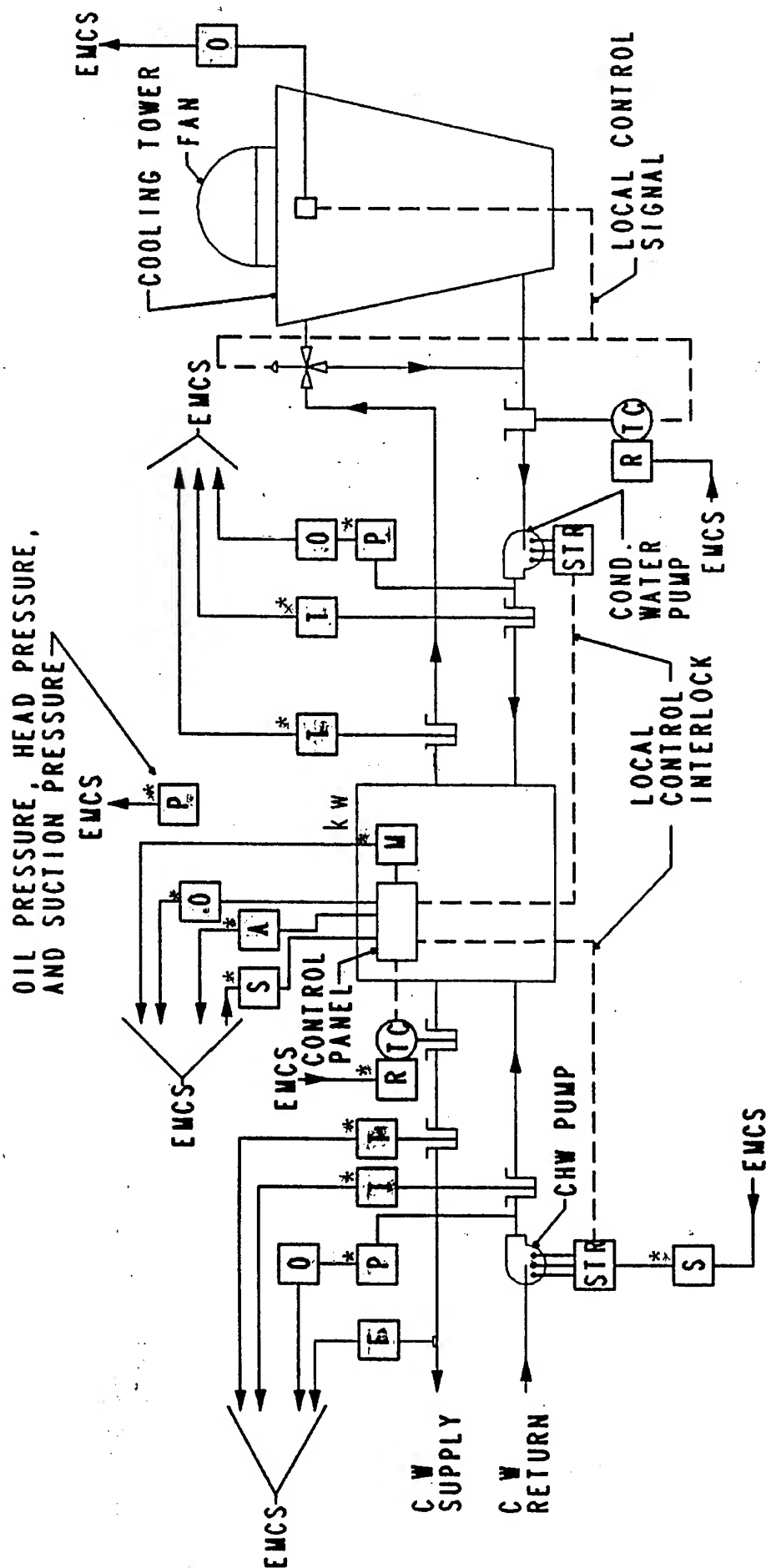
FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	20987.
PEAK DAY GAS CONSUMP., 1000 CU FT	287.
ELECTRICAL CONSUMPTION, KWH	883113.
PEAK KW DEMAND (15 MIN BASIS)	525.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	883113.
ON-PEAK KW DEMAND (15 MIN BASIS)	525.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
BOILER OPERATING HOURS	
BOILER 1	1507
BOILER 2	980
BOILER 3	570
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

## CENTRAL PLANT 730 CHILLER ECO-2

## SYSTEM C1 NORMAL HEATING AND COOLING SEASONS

\*\* TOTAL \*\*

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	20987.
PEAK DAY GAS CONSUMP., 1000 CU FT	287.
ELECTRICAL CONSUMPTION, KWH	545601.
PEAK KW DEMAND (15 MIN BASIS)	362.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	545601.
ON-PEAK KW DEMAND (15 MIN BASIS)	362.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	0
BOILER OPERATING HOURS	
BOILER 1	1507
BOILER 2	980
BOILER 3	570
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.


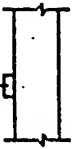


Water cooled chiller

\* - Points included on proposed EMCS design, existing.  
All other points are new.

→ EMCS SIGNAL TRANSMITTED TO EMCS  
 ← EMCS SIGNAL TRANSMITTED FROM EMCS

[A]	ALARM CONTACT SIGNAL
[E]	ECONOMIZER CONTROL INTERFACE
[F]	FLOW INDICATION
[FL]	FLAME INDICATION
[H]	HUMIDITY INDICATION
[P]	PRESSURE INDICATION
[LV]	LEVEL INDICATION
[M]	METER
[O]	ON-OFF STATUS SIGNAL
[DP]	DIFFERENTIAL PRESSURE SWITCH
[R]	CONTROLLER RESET INTERFACE
[S]	START-STOP INTERFACE
[T]	TEMPERATURE INDICATION
[V]	VENTILATION/RECIRCULATION CONTROL
[PS]	POSITION
[O <sub>2</sub> ]	FLUE GAS ANALYSIS, OXYGEN
[C <sub>o</sub> ]	FLUE GAS ANALYSIS, CARBON MONOXIDE

[FD]	FURNACE DRAFT DIFFERENTIAL PRESSURE
[DS]	HIGH-LOW DEMAND SIGNAL SELECTOR
[TC]	TEMPERATURE CONTROLLER
[PC]	PRESSURE CONTROLLER
[STR]	MOTOR STARTER
	SENSOR INSTALLED IN THERMOMETER WELL
	SENSOR INSTALLED IN DUCT OR PLENUM
CHW	CHILLED WATER
EA	EXHAUST AIR
SA	SUPPLY AIR
RA	RETURN AIR
OA	OUTSIDE AIR
MA	MIXED AIR
WB	WET BULB
DB	DRY BULB
OAD	OUTSIDE AIR DAMPER
RAD	RETURN AIR DAMPER
EAD	EXHAUST AIR DAMPER
MZD	MULTIZONE DAMPER
RH	RELATIVE HUMIDITY

Symbols and Abbreviations

# **COST ESTIMATE ANALYSIS**

PROJECT ENERGY SURVEY OF ARMY BOILER AND CHILLER										INVITATION NO./CONTRACT NO.				EFFECTIVE PRICING		DATE PREPARED	
LOCATION FT. SILL, OKLAHOMA										DACA 59-90-C-0087				DATE APR. 91		04-Apr-91	
										CODE A <input type="checkbox"/> CODE B <input type="checkbox"/> CODE C <input type="checkbox"/>				DRAWING NO.		SHT OF	
										OTHER <input type="checkbox"/>							
														ESTIMATOR		CHECKED BY	
														KC		CEL	
														TOTAL		SHIPPING	
														Unit		Total	
														Wt		Wt	
CHILLER ECO-2	BLDG. 730																
OPTIMIZE CHILLER SEQUENCE																	
TASK DESCRIPTION		No. Of Units	Unit Meas	MH/ Unit	Total Hrs	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost
INSTRUMENTATION FOR 2 CHILLERS																	
CHWS/R TEMPERATURE SENSOR	*	2	LS			176	352			328.00	656.00			328.00	656.00		
CHWS/R TEMPERATURE SENSOR		4	LS			176	704			328.00	1312.00			328.00	1312.00		
CNWS/R TEMPERATURE SENSOR	*	2	LS			176	352			328.00	656.00			328.00	656.00		
CNWS/R TEMPERATURE SENSOR		4	LS			176	704			328.00	1312.00			328.00	1312.00		
INSERT. FLOW METER		3	LS			197	591			764.00	2292.00			764.00	2292.00		
CHWP ST/SP	*	1	LS			39.2	39.2			226	226			226	226		
CHWP ST/SP		1	LS			39	39			226.00	226.00			226.00	226.00		
CNWP ST/SP	*	1	LS			39	39			226.00	226.00			226.00	226.00		
CNWP ST/SP		1	LS			39	39			226.00	226.00			226.00	226.00		
DP (LIQUID) PUMP STATUS	*	2	LS			155	310			205.00	410.00			205.00	410.00		
DP (LIQUID) PUMP STATUS		2	LS			155	310			205.00	410.00			205.00	410.00		
COOLING TOWER ST/SP		2	LS			39	78			226.00	452.00			226.00	452.00		
COOLING TOWER ST/SP STATUS		2	LS			104	208			53.00	106.00			53.00	106.00		
CHW TEMP CONTROL	*	1	EA	5.5	5.5	20	108			558.00	558.00			558.00	558.00		
CHILLER ST/SP	*	1	EA	2.0	2.0	20	39			226.00	226.00			226.00	226.00		
CHW TEMP CONTROL		1	EA	5.5	5.5	20	108			558.00	558.00			558.00	558.00		
CHILLER ST/SP		1	EA	2.0	2.0	20	39			226.00	226.00			226.00	226.00		
KW TRANSDUCER	*	1	LS			226	226			374.00	374.00			374.00	374.00		
KW TRANSDUCER		1	LS			226	226			374.00	374.00			374.00	374.00		
CURRENT TRANSDUCER		2	LS			126	252			270.00	540.00			270.00	540.00		
FID PANEL & ACCESSORIES	*	1	LS			208	208			3681.00	3681.00			3681.00	3681.00		
FID SOFTWARE COMMISSIONING		1	EA	6.0	6.0	45	270										
FID TESTING		1	EA	6.0	6.0	45	270										
CREDIT FROM EMCS PROJECT	*						-1673										
SUBTOTAL							\$3,839										
OVERHEAD, BOND		16%					\$614										
PROFIT		10%					\$384										
COST SUB-TOTAL							\$4,837										
CONTINGENCY		20%					\$967										
SUBTOTAL							\$5,804										
S&A		5.5%					\$319										
TOTAL							\$6,124										
SHEET																	

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C730ECO

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER OPTIMIZATION

ANALYSIS DATE: 04-08-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	17952.
B. SIOH	\$	988.
C. DESIGN COST	\$	1078.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	18016.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	18016.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	1154.	\$ 4632.	8.78	40670.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		1154.	\$ 4632.		\$ 40670.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	2418.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	22028.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) / COST(-) (3A2+3Bd4)	\$	22028.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	13421.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=	3.00	
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE))	\$	7050.
5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C)	\$	62698.
6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)=	3.48	
(IF < 1 PROJECT DOES NOT QUALIFY)		
7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4		2.56

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-3  
**SYSTEM MODIFICATION:** MINOR RENOVATION, CHILLER 1&3  
**SYSTEMS TO MODIFY:** CHILLER 1,3

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-3, renovate or replace existing chillers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	525	883,000	20,988	24,002
ECO	503	881,000	20,988	23,995
Savings (Baseline-ECO)	22	2,000	0	7

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 7 MMBtu/Yr X \$4.0141 /MMBtu = \$27 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$27 + \$0 = \$27 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 22 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$472 per year  
 Maintenance: = (-) \$3,000 per year  
 Total: \$472 - \$3,000 = (\$2,528) per year

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTAL PALNT 730 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING SEASONS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	20987.
PEAK DAY GAS CONSUMP., 1000 CU FT	287.
ELECTRICAL CONSUMPTION, KWH	883113.
PEAK KW DEMAND (15 MIN BASIS)	525.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	883113.
ON-PEAK KW DEMAND (15 MIN BASIS)	525.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
BOILER OPERATING HOURS	
BOILER 1	1507
BOILER 2	980
BOILER 3	570
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 730 CHILLER ECO-3

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING SEASONS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	20987.
PEAK DAY GAS CONSUMP., 1000 CU FT	287.
ELECTRICAL CONSUMPTION, KWH	880838.
PEAK KW DEMAND (15 MIN BASIS)	503.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	880838.
ON-PEAK KW DEMAND (15 MIN BASIS)	503.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
BOILER OPERATING HOURS	
BOILER 1	1507
BOILER 2	980
BOILER 3	570
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C730EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER MAINTENANCE

ANALYSIS DATE: 04-29-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	6000.
B. SIOH	\$	330.
C. DESIGN COST	\$	360.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	6021.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	6021.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	7.	\$ 27.	8.78	241.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		7.	\$ 27.		\$ 241.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-2528.
(1) DISCOUNT FACTOR (TABLE A)	9.11	
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-23030.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-23030.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	79.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -2501.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -22789.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -3.78  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -2.41

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	712	0	0	0

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	712 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$15,268		per year
Maintenance:	= (-)		\$0		per year
<b>Total:</b>	<b>\$15,268</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$15,268 per year</b>

# A new application of an old idea that can cut air conditioning energy costs in half.

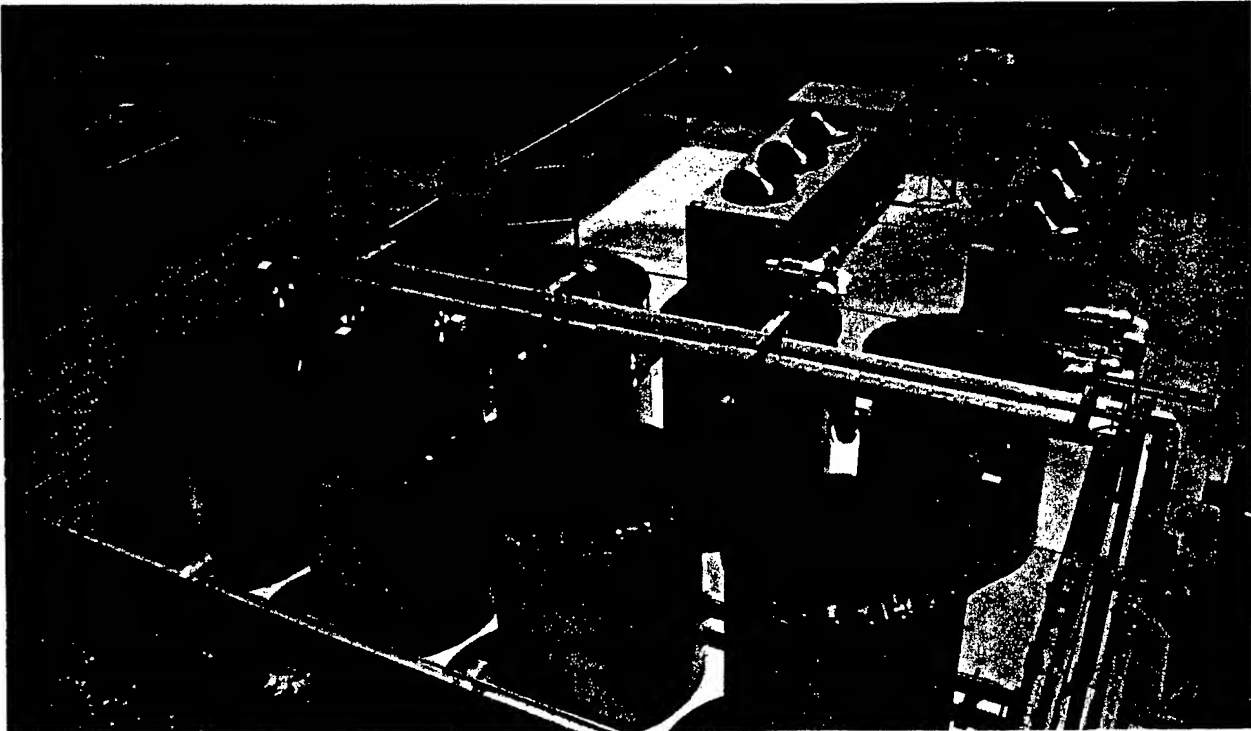
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes—90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.

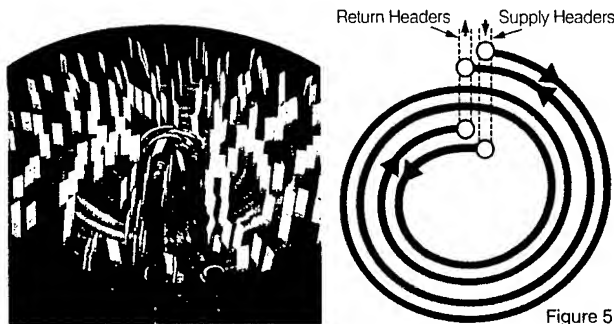


Figure 5

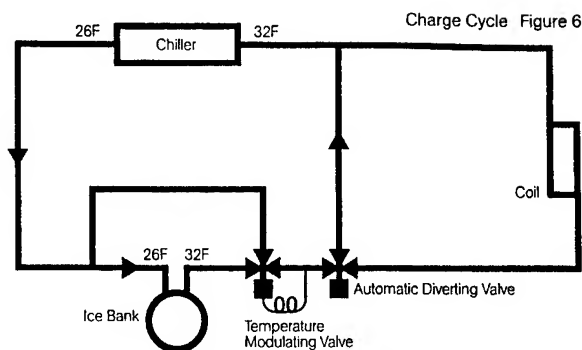
Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

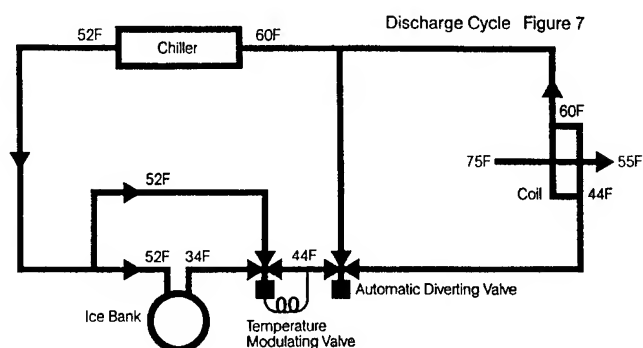
During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.



Charge Cycle Figure 6



Discharge Cycle Figure 7

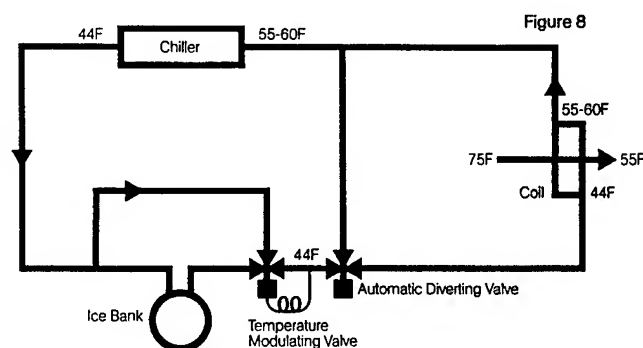


Figure 8

The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's Dowtherm® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 730EC4

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000      ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM

ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	192000.
B. SIOH	\$	10560.
C. DESIGN COST	\$	11520.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	192672.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	192672.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	15268.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	177872.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	177872.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	0.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		.00
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 15268.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 177872.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .92  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 12.62

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(A)  
**SYSTEM MODIFICATION:** TWO SPEED FANS FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	32,299	--	110
ECO	--	14,858	--	51
Savings (Baseline-ECO)	0	17,441	0	60

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	60 MMBtu/Yr	X	\$4.0141 /MMBtu =	\$239 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu =	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$239 +</b>	<b>\$0</b>	<b>=</b>	<b>\$239 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

$(\text{Total exit air design enthalpy minus average monthly enthalpy, part 2}) / (\text{entering air design enthalpy})$

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

$(\% \text{ load on plant, part 3} * \text{monthly peak load, part 3}) / (\text{Highest monthly peak load, part 3}) * (1 / \text{ratio of monthly enthalpy, part 4})$

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle is in direct proportion to the % design load on the tower, (part 6) =

$\text{kWh per bin} = (\text{total fan power kW}) * (\% \text{ design load, part 5} * 4 \text{ hours per bin} * \text{days per month})$

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input. The calculations take into account multi-cell towers (part 7). The control sequence is:

- 0-25% load, fan 1, half speed cycling.
- 25-50% load, fan 1 half speed running, fan 2 half speed cycling.
- 50-75% load, fan 1 full speed cycling, fan 2 half speed running.
- 75-100% load, fan 1 full speed running, fan 2 full speed cycling.

kWh per bin, for % design loads less than 25% load = (fan 1 power kW) \* 14% \* (% design load / 25) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 25% to 50% load = (fan 1 power kW \* 14% \* 4 hours per bin \* days per month) \* ( fan 2 power kW \* 14% \* ((% design load - 25) / 25) \* 4 hours per bin \* days per month )

kWh per bin, for % design loads 50% to 75% load = (fan 2 power kW \* 14% \* 4 hours per bin \* days per month) \* ( fan 1 power kW \* ((% design load - 50) / 25) \* 4 hours per bin \* days per month )

kWh per bin, for % design loads 75% to 100% load = ( fan 1 power kW \* 4 hours per bin \* days per month ) + ( fan 2 power kW \* ((% design load - 75) / 25) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 730	
DESIGN CONDITIONS	
– WBT (DB, DEG F)	77
– WATER FLOW (gpm)	2600
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
– AIR FLOW (LBS/MIN)	10790
HEAT REJECTION CAPACITY (Btu/min)	
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	40.57
TOTAL ENTHALPY	60.57
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	162929
MOTOR DATA	
– FAN 1 POWER (kW)	23
– FAN 2 POWER (kW)	23

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

WET-BULB AVERAGES (4 hour bins)							DESIGN WB
	1–4	5–8	9–12	13–16	17–20	21–24	
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	77
MAY	57.1	56.6	61.2	63.9	63	59.4	77
JUNE	66.8	66.6	69.9	71	70.5	68.2	77
JULY	70.8	70.9	74.5	76	74.9	72.6	77
AUGUST	66.9	67	71	72	71	68.5	77
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	77
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	77

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN ENTHALPY
	1–4	5–8	9–12	13–16	17–20	21–24	
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	40.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	40.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	40.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	40.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	40.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	40.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	40.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD
	1-4	5-8	9-12	13-16	17-20	21-24	(Btuh)
APRIL	0	0.8	0.5	0.4	0	0	992000
MAY	0	0.9	0.6	0.8	0	0	4312000
JUNE	0	0.9	0.6	0.8	0	0	11526000
JULY	0	0.9	0.6	0.8	0	0	11526000
AUGUST	0	0.9	0.6	0.8	0	0	11526000
SEPTEMBER	0	0.9	0.6	0.8	0	0	11526000
OCTOBER	0	0.8	0.5	0.4	0	0	2244000

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	2.0	2.1	2.0	1.8	1.9	2.0	22
MAY	1.8	1.8	1.7	1.6	1.6	1.7	23
JUNE	1.5	1.5	1.3	1.3	1.3	1.4	22
JULY	1.3	1.3	1.1	1.1	1.1	1.2	23
AUGUST	1.5	1.4	1.3	1.2	1.3	1.4	23
SEPTEMBER	1.5	1.5	1.4	1.4	1.4	1.5	22
OCTOBER	2.0	2.0	1.9	1.8	1.9	1.9	23

% DESIGN LOAD							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	3.3	2.2	1.9	0.0	0.0	22
MAY	0.0	18.5	13.5	19.1	0.0	0.0	23
JUNE	0.0	61.5	45.2	62.5	0.0	0.0	22
JULY	0.0	70.0	53.5	76.2	0.0	0.0	23
AUGUST	0.0	62.2	46.8	64.7	0.0	0.0	23
SEPTEMBER	0.0	58.8	42.4	58.2	0.0	0.0	22
OCTOBER	0.0	7.8	5.2	4.3	0.0	0.0	23

SINGLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	134	89	75	0	0	
MAY	0	784	571	808	0	0	
JUNE	0	2490	1829	2528	0	0	
JULY	0	2963	2264	3224	0	0	
AUGUST	0	2631	1982	2737	0	0	
SEPTEMBER	0	2382	1715	2357	0	0	
OCTOBER	0	329	221	184	0	0	
TOTAL	0	11714	8671	11914	0	0	32299

TWO SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	38	25	21	0	0	
MAY	0	219	160	226	0	0	
JUNE	0	1216	512	1291	0	0	
JULY	0	1990	592	2513	0	0	
AUGUST	0	1327	555	1538	0	0	
SEPTEMBER	0	999	480	949	0	0	
OCTOBER	0	92	62	51	0	0	
TOTAL	0	5881	2387	6591	0	0	14858

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	0	34	13	37	0	0	
JUNE	0	1178	467	1232	0	0	
JULY	0	1815	810	2340	0	0	
AUGUST	0	1272	544	1431	0	0	
SEPTEMBER	0	1031	385	999	0	0	
OCTOBER	0	2	1	0	0	0	
TOTAL	0	5332	2219	6039	0	0	13590



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 730EC5A

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	14114.
B. SIOH	\$	777.
C. DESIGN COST	\$	847.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	14164.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	14164.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	60.	\$ 239.	11.37	2717.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		60.	\$ 239.		\$ 2717.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	0.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	0.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	0.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	897.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 239.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 2717.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .19  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 59.27

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	32,299	--	110
ECO	--	13,590	--	46
Savings (Baseline-ECO)	0	18,709	0	64

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 64 MMBtu/Yr X \$4.0141 /MMBtu = \$256 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$256 + \$0 = \$256 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$579 per year  
 Total: \$0 - \$579 = (\$579)per year

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input. The calculations take into account multi-cell towers (part 7). The control sequence is:

- 0-25% load, fan 1, half speed cycling.
- 25-50% load, fan 1 half speed running, fan 2 half speed cycling.
- 50-75% load, fan 1 full speed cycling, fan 2 half speed running.
- 75-100% load, fan 1 full speed running, fan 2 full speed cycling.

kWh per bin, for % design loads less than 25% load = (fan 1 power kW) \* 14% \* (% design load / 25) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 25% to 50% load = (fan 1 power kW \* 14% \* 4 hours per bin \* days per month) \* (fan 2 power kW \* 14% \* ((% design load - 25) / 25) \* 4 hours per bin \* days per month)

kWh per bin, for % design loads 50% to 75% load = (fan 2 power kW \* 14% \* 4 hours per bin \* days per month) \* (fan 1 power kW \* ((% design load - 50) / 25) \* 4 hours per bin \* days per month)

kWh per bin, for % design loads 75% to 100% load = (fan 1 power kW \* 4 hours per bin \* days per month) + (fan 2 power kW \* ((% design load - 75) / 25) \* 4 hours per bin \* days per month)

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = (total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 730	
DESIGN CONDITIONS	
– WBT (DB, DEG F)	77
– WATER FLOW (gpm)	2600
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
– AIR FLOW (LBS/MIN)	10790
HEAT REJECTION CAPACITY (Btu/min)	
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	40.57
TOTAL ENTHALPY	60.57
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	162929
MOTOR DATA	
– FAN 1 POWER (kW)	23
– FAN 2 POWER (kW)	23

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET-BULB AVERAGES (4 hour bins)						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	77
MAY	57.1	56.6	61.2	63.9	63	59.4	77
JUNE	66.8	66.6	69.9	71	70.5	68.2	77
JULY	70.8	70.9	74.5	76	74.9	72.6	77
AUGUST	66.9	67	71	72	71	68.5	77
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	77
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	77

	ENTHALPY FOR AVERAGE WET-BULBS						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	40.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	40.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	40.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	40.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	40.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	40.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	40.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD
	1-4	5-8	9-12	13-16	17-20	21-24	(Btuh)
APRIL	0	0.8	0.5	0.4	0	0	992000
MAY	0	0.9	0.6	0.8	0	0	4312000
JUNE	0	0.9	0.6	0.8	0	0	11526000
JULY	0	0.9	0.6	0.8	0	0	11526000
AUGUST	0	0.9	0.6	0.8	0	0	11526000
SEPTEMBER	0	0.9	0.6	0.8	0	0	11526000
OCTOBER	0	0.8	0.5	0.4	0	0	2244000

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	2.0	2.1	2.0	1.8	1.9	2.0	22
MAY	1.8	1.8	1.7	1.6	1.6	1.7	23
JUNE	1.5	1.5	1.3	1.3	1.3	1.4	22
JULY	1.3	1.3	1.1	1.1	1.1	1.2	23
AUGUST	1.5	1.4	1.3	1.2	1.3	1.4	23
SEPTEMBER	1.5	1.5	1.4	1.4	1.4	1.5	22
OCTOBER	2.0	2.0	1.9	1.8	1.9	1.9	23

% DESIGN LOAD							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	3.3	2.2	1.9	0.0	0.0	22
MAY	0.0	18.5	13.5	19.1	0.0	0.0	23
JUNE	0.0	61.5	45.2	62.5	0.0	0.0	22
JULY	0.0	70.0	53.5	76.2	0.0	0.0	23
AUGUST	0.0	62.2	46.8	64.7	0.0	0.0	23
SEPTEMBER	0.0	58.8	42.4	58.2	0.0	0.0	22
OCTOBER	0.0	7.8	5.2	4.3	0.0	0.0	23

SINGLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	134	89	75	0	0	
MAY	0	784	571	808	0	0	
JUNE	0	2490	1829	2528	0	0	
JULY	0	2963	2264	3224	0	0	
AUGUST	0	2631	1982	2737	0	0	
SEPTEMBER	0	2382	1715	2357	0	0	
OCTOBER	0	329	221	184	0	0	
TOTAL	0	11714	8671	11914	0	0	32299

TWO SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	38	25	21	0	0	
MAY	0	219	160	226	0	0	
JUNE	0	1216	512	1291	0	0	
JULY	0	1990	592	2513	0	0	
AUGUST	0	1327	555	1538	0	0	
SEPTEMBER	0	999	480	949	0	0	
OCTOBER	0	92	62	51	0	0	
TOTAL	0	5881	2387	6591	0	0	14858

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	0	34	13	37	0	0	
JUNE	0	1178	467	1232	0	0	
JULY	0	1815	810	2340	0	0	
AUGUST	0	1272	544	1431	0	0	
SEPTEMBER	0	1031	385	999	0	0	
OCTOBER	0	2	1	0	0	0	
TOTAL	0	5332	2219	6039	0	0	13590



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 730EC5B  
 LCCID 1.035  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3  
 PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: VARIABLE SPEED COOLING TOWER  
 ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	9649.
B. SIOH	\$	531.
C. DESIGN COST	\$	579.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	9683.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	9683.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	64.	\$ 256.	11.37	2914.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		64.	\$ 256.		\$ 2914.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-579.
(1) DISCOUNT FACTOR (TABLE A)	11.65		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	-6745.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-6745.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)		\$	962.
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F= _____			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -323.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -3831.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.40  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -30.01

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.

It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	41	85,430	0	292

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 292 MMBtu/Yr X \$4.0141 /MMBtu = \$1,170 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$1,170 + \$0 = \$1,170 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 41 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$879 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$879 - \$0 = \$879 per year**

[ECO-SHT.WK3]

## HIGH EFFICIENCY MOTOR REPLACEMENT

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR
730	CWP-1	150.0	179.0	147.0	0.87	460	90.19%	95.00%	5.73	2641	15120	\$330
	CWP-2	150.0	179.0	148.0	0.91	460	86.22%	95.00%	11.50	1873	21539	\$542
	CNWP-1	50.0	118.0	107.0	0.98	230	80.97%	93.00%	6.67	2641	17629	\$385
	CNWP-2	50.0	118.0	107.0	0.99	230	80.15%	93.00%	7.27	468	3405	\$203
	CNWP-3	NI	NI	NI								
	CTM-1	30.0	71.4	70.7	0.93	230	84.60%	92.40%	2.61	702	1834	\$81
	CTM-2	30.0	71.4	71.0	0.87	230	90.44%	92.40%	0.58	702	405	\$18
	HWP-1	50.0	125.0	117.5	0.87	230	86.10%	93.00%	3.51	3624	12722	\$250
	HWP-2	50.0	125.0	118.0	0.87	230	86.10%	93.00%	3.53	3624	12776	\$251
		DEMAND CREDIT		\$888	MMBtu		292	TOTAL	41		85430	\$2,058
914	CWP-1	40.0	48.0	41.3	0.87	460	89.69%	93.00%	1.14	3672	4178	\$82
	CNWP-1	15.0	19.0	14.4	0.82	460	90.15%	90.20%	0.01	3672	23	\$0
	CTM-1	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	CTM-2	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	HWP-1	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33
	HWP-2	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34
		DEMAND CREDIT		\$111	MMBtu		30	TOTAL	5		8932	\$233
2812	CWP-1	20.0	27.0	23.0	0.77	460	90.07%	91.00%	0.16	3672	586	\$11
	CNWP-1	25.0	31.5	26.5	0.82	460	91.18%	91.70%	0.11	3672	394	\$8
	CTM-1	15.0	18.6	18.6	0.87	460	86.79%	90.20%	0.56	1167	655	\$21
	HWP-1	7.5	21.6	18.5	0.87	230	74.74%	88.50%	1.33	5163	6888	\$123
	HWP-2	7.5	21.6	19.0	0.87	230	74.74%	88.50%	1.37	3672	5031	\$98
		DEMAND CREDIT		\$76	MMBtu		46	TOTAL	4		13554	\$261
3442	CWP-1	60.0	73.0	63.0	0.84	460	91.62%	94.50%	1.40	3672	5158	\$101
	CWP-2	60.0	73.0	63.4	0.84	460	91.62%	94.50%	1.41	3672	5191	\$101
	CNWP-1	40.0	52.0	41.0	0.78	460	92.34%	93.00%	0.20	3672	721	\$14
	CNWP-2	40.0	52.0	35.8	0.78	460	92.34%	93.00%	0.17	3672	629	\$12
	CTM-1	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-2	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-3	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-4	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
		DEMAND CREDIT		\$90	MMBtu		44	TOTAL	4		12880	\$266
4701	CWP-1	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CWP-2	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CNWP-1	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CNWP-2	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CTM-1	20.0	24.6	18.2	0.87	460	87.50%	91.00%	0.55	650	361	\$17
	CTM-2	15.0	19.2	16.5	0.87	440	87.90%	90.20%	0.32	650	206	\$10
		DEMAND CREDIT		\$65	MMBtu		16	TOTAL	3		4605	\$128
5676	HCP-1	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	HCP-2	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	10.5	9	0.79	460	84.66%	88.50%	0.29	1160	337	\$11
		DEMAND CREDIT		\$94	MMBtu		83	TOTAL	4		24287	\$427
5678	HCP-1	2.0	6.5	5.9	0.83	208	76.76%	84.00%	0.20	7296	1445	\$24
	HCP-2	2.0	6.5	5.7	0.83	208	76.76%	84.00%	0.19	7296	1396	\$23
	HCP-3	1.5	4.8	4.5	0.83	230	70.51%	84.00%	0.34	7296	2474	\$41
	HCP-4	2.0	6.3	5.8	0.83	230	71.62%	84.00%	0.39	7296	2878	\$48
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	11	9.6	0.75	460	85.12%	88.50%	0.26	1139	293	\$10
		DEMAND CREDIT		\$64	MMBtu		49	TOTAL	3		14412	\$262



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 730EC6  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR  
 ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	47675.
B. SIOH	\$	2623.
C. DESIGN COST	\$	2861.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	47843.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	47843.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	292.	\$ 1171.	11.37	13309.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		292.	\$ 1171.		\$ 13309.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)	11.65	\$	879.
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	10240.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ 10240.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33) \$ 4392.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = .37

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 2050.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 23549.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .49  
 (IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 23.34

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 7  
**SYSTEM MODIFICATION:** INSTALL INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-7, install instrumentation to facilitate efficient operation of boiler plant. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	0	89	89

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	89 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$260 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$260</b>	<b>=</b>	<b>\$260 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$0 per year
Maintenance:	=	(-)			\$255 per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$255</b>	<b>=</b>	<b>(\$255) per year</b>

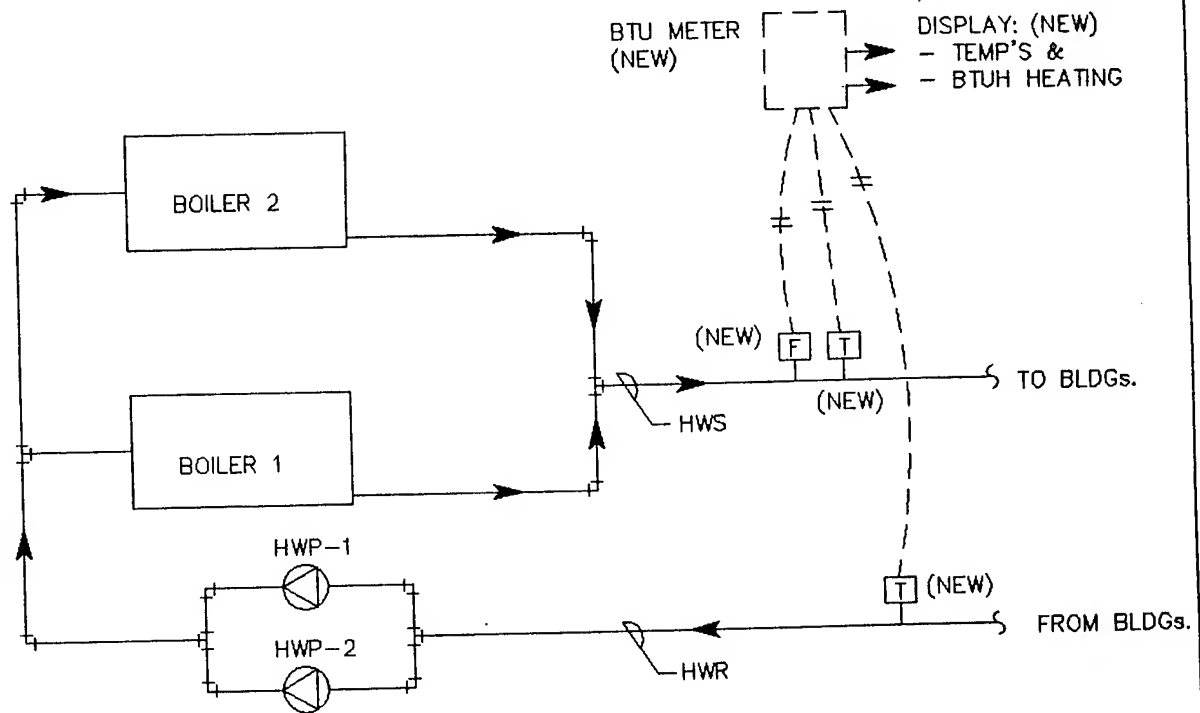
[ECO-SHT.WK3]

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (1%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS STANDBY SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0		
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	51.62	\$150.74
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.82	\$160.09
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	\$159.27
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0		
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0		
					TOTAL	9.41	0.0941	2160	160.99	\$470.10
6003	1	STEAM-12	KEWANEE	L39-350-605	11.72	9.12	0.0912	0		
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0		
	3	STEAM-12	KEWANEE	L36-350-605	11.72	9.37	0.0937	720	67.45	\$196.96
					TOTAL	6.16	0.0616	0		
730	1	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	720	44.34	\$129.47
	2	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	720	44.51	\$129.96
	3	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANEE	CAT#7L280-KG-06	2.66	2.11	0.0211	0		
					TOTAL	1.40	0.0140	1440	88.84	\$259.43
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3562	1.80	1.40	0.0140	0		
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.77	0.0277	0		
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.62	\$60.21
					TOTAL	1.80	0.0180	720	12.93	\$37.76
5676	1	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
					TOTAL	1.50	0.0150	720	10.79	\$31.50
5678	1	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
					TOTAL	1.29	0.0129	720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.81	1.22	0.0122	0		
	2	HW	RAY-PAK	EA 200ITB	1.61	1.22	0.0122	0		
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0		
					TOTAL	8.43	0.0843	720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
					TOTAL	8.43	0.0843	720	60.73	\$177.33

[BOILERS WK3]

# ECO-7, INSTRUMENTATION FOR BOILER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[B-ECO-7.DWG]



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B730EC1

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER INSTRUMENTATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	4248.
B. SIOH	\$	234.
C. DESIGN COST	\$	255.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	4263.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	4263.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	89.	\$ 259.	12.48	3237.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		89.	\$ 259.		\$ 3237.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-255.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-2323.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-2323.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1068.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 4.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 914.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .21  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 966.12

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 10  
**SYSTEM MODIFICATION:** OXYGEN TRIM FOR BURNERS  
**SYSTEMS TO MODIFY:** BOILER 1, 2, 3, AND 4

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-10, install oxygen trim for burners.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	20,988	20,988
ECO	--	--	20,880	20,880
Savings (Baseline-ECO)	0	0	108	108

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 108 MMBtu/Yr X \$2.92 /MMBtu = \$315 per year  
**Total Energy Cost Savings: \$0 + \$315 = \$315 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$2,411 per year  
**Total: \$0 - \$2,411 = (\$2,411) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTAL PALNT 730 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING SEASONS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	20987.
PEAK DAY GAS CONSUMP., 1000 CU FT	287.
ELECTRICAL CONSUMPTION, KWH	883113.
PEAK KW DEMAND (15 MIN BASIS)	525.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	883113.
ON-PEAK KW DEMAND (15 MIN BASIS)	525.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
BOILER OPERATING HOURS	
BOILER 1	1507
BOILER 2	980
BOILER 3	570
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 730 BOILER ECO-4

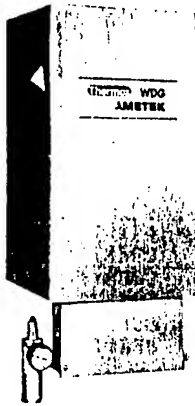
\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING SEASONS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	20880.
PEAK DAY GAS CONSUMP., 1000 CU FT	286.
ELECTRICAL CONSUMPTION, KWH	883026.
PEAK KW DEMAND (15 MIN BASIS)	525.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	883026.
ON-PEAK KW DEMAND (15 MIN BASIS)	525.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
BOILER OPERATING HOURS	
BOILER 1	1506
BOILER 2	974
BOILER 3	562
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# SPECIFICATIONS - AIR-MIZER II SYSTEM

## SENSOR



**Nominal Dimensions:** 14 1/2" H x 10 1/4" W x 10" D (37.2 x 26 x 25.4 cm)

**Enclosure:** Weather resistant—S.S. case, nickel plated carbon steel base

**Weight:** 55 pounds (25 kg)

**Accuracy:**  $\pm 1\%$  of net excess oxygen

**Repeatability:**  $\pm 0.2\%$  of measured value

**Response:** 90% of full scale in less than 5 seconds

**Drift:** Less than 0.1% of sensor cell output per month

**Ambient Temperatures:** -5 to +175°F (-20.5 to +79°C)

**Sample Temperatures:** Up to 1300°F (704°C) with standard probe

**Sample Flow Rate:** 0.1 to 120 scfh (0.47 to 56.65 liters/minute)

**Air Aspirator Requirements:** 10 to 20 scfh (4.72 to 14.16 liters/min) at 15-100 psi (1.05 to 7.037 kg/cm<sup>2</sup>) (Aspirator air regulator furnished with sensor normally set at 2-7 psi; 0.14 - 0.49 kg/cm<sup>2</sup>)

**Calibration:** With analyzed oxygen in nitrogen sample. Calibration port provided.

## CONTROL UNIT

**Nominal Dimensions:** 12 1/2" H x 10 1/4" W x 9 1/4" D (32.1 x 27.6 x 23.2 cm)

**Enclosure:** Wall/panel mounted—meets the requirements for NEMA 4 areas

**Weight:** 22 pounds (10 kg)

**Temperature Control:** On-Off by microprocessor ( $\pm 1^\circ\text{C}$ )

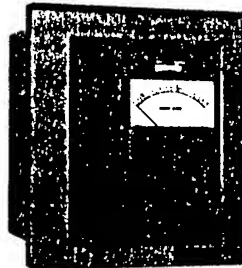
**Linearization:** 256 segments from 20% to 0.2% O<sub>2</sub>, (218 from 10% to 0.2%), by microprocessor

**Controller Action:** On-Off—"On" time adjustable 2-20 seconds. "Off" time adjustable 2-60 seconds.

Deadband:  $\pm 0.25\%$  oxygen. LED's indicate motor driving.

Will not allow decrease in air when O<sub>2</sub> is below 0.5% oxygen. Air flow will increase to +15% max. If O<sub>2</sub> level is above 12%.

**Setpoint:** 0 to 10% oxygen by either of: A. Two banks of 5 slide pots, (Dual Fuel) selectable by slide switch; proper pot or pots connected to processor by switch in actuator. B. Manual pot on panel A or B selected by Remote/Local switch on panel. Setpoint indicated by edge reading meter (0-10%)



**Manual Control:** Manual/Auto switch and Increase—decrease push buttons (Spring return switch inside control unit can override all control actions in the event of processor failure).

**Ready Indicator:** On at temperature set point. Off below temperature set point. Flashes above temperature set point. O<sub>2</sub> Control in "manual" when below set point.

**Oxygen Scale:** 20.9 to 0.1% O<sub>2</sub>, Logarithmic

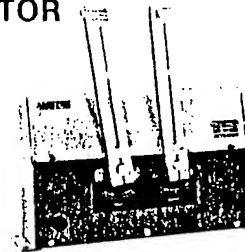
**Alarms:** High and Low O<sub>2</sub>, adjustable 0.2 to 20%. RTD Failure (shuts down temperature control, and puts O<sub>2</sub> control in "manual").

**Increase Air Override:** Contact closure from optional combustibles or smoke detector alarm will cause increase in air signal on each control pulse regardless of O<sub>2</sub> vs. O<sub>2</sub> setpoint relationship. Once combustibles contact opens, normal control will resume. This maintains air flow at a level where maximum allowable combustibles or smoke is not exceeded.

**Ambient Temperature Limits:** 32°F to 140°F (0 to +60°C)

**Recorder Output:** 0-100 mv = 0-20% O<sub>2</sub> Linear (0-50 mv = 0-10%) Other current or voltages outputs optional

## ACTUATOR



**Overall Size:** 17 1/2" L x 4" W x 10 1/4" H (44.5 x 10.2 x 26 cm)

**Weight:** 16.5 pounds (7.5 kg)

**Angular Travel (Input Arm):** 60°

**Linear Link Travel:** Adjustable 4" to 10" at 4" to 10" Radius (10.2 to 25.4 cm at 10.2 to 25.4 cm Radius)

**Linear Link Force:** 100 pounds at 4" Radius (45.5 kg at 10.2 cm Radius)

70 pounds at 6" Radius (31.8 kg at 15.2 cm Radius)

40 pounds at 10" Radius (18.2 kg at 25.4 cm Radius)

**Case:** Suitable for areas requiring NEMA 2 equipment (Drip proof indoor)

**Correction:** -15% to +15% (.85 to 1.15 gain) of normal air flow

**Speed:** 60 seconds from -15% to +15% correction (max.)

**Load Indication:** 9 position shorting switch tied to input arm

**Brake:** Internal brake will hold load at any above rated force without "coasting"

**Ambient Temperature Limits:** 0°F to 160°F (-18 to +71°C)



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 730EC10

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER O2 TRIM CONTROL

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	28108.
B. SIOH	\$	1546.
C. DESIGN COST	\$	1687.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	28207.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	28207.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	108.	\$ 315.	12.48	3936.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		108.	\$ 315.		\$ 3936.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-2411.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-21964.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-21964.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1299.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -2096.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -18029.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.64  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -13.46

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 730  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 14  
**SYSTEM MODIFICATION:** NEW CHW PUMP FOR 300 TON CHILLER  
**SYSTEMS TO MODIFY:** CHILLER PLANT

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-14, install new pump to match load requirements. It was estimated that the electrical energy can be saved by installing smaller pump to match the load, based on the pump operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	144,560	0	493

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 493 MMBtu/Yr X \$4.0141 /MMBtu = \$1,980 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$1,980 + \$0 = \$1,980 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$0 - \$0 = \$0 per year**

[ECO-SHT.WK3]

**E M C ENGINEERS, INC.**

Denver • Colorado Springs • Atlanta • West Germany

JOB FL. SILL CENTRAL PLANT 3002.000  
 SHEET NO. 1 OF 1  
 CALCULATED BY KC DATE 4-3-91  
 CHECKED BY CEL DATE 4-19-91  
 SCALE CHILLER ECO

ADDITIONAL PUMP FOR CHILLED WATER DISTRIBUTION SYSTEM, BLDG 730

$$FLOW = \frac{TONS \times 12000}{\Delta T \times 500} = \frac{300 \times 12000}{(53-38) \times 500}$$

$$FLOW = 480 \text{ GPM @ } 290 \text{ TDH-FL.}$$

$$BHP = \frac{TDH-FL \times GPM}{3960 \times 0.8} = \frac{290 \times 480}{3960 \times 0.8}$$

$$BHP = 43.94 \text{ BHP}$$

$$HP = \frac{BHP}{\% \text{ EFF (PUMP)}} = \frac{43.94}{80\%} = 54.9 \text{ HP.}$$

$$KW = \frac{HP \times 0.746}{\% \text{ EFF (MOTOR)}} = \frac{54.9}{93\%} = 44.1 \text{ KW}$$

PEAK COOLING LOAD IS 9.6 MMBtu/h (800 TON)

$$300 \text{ TONS CHILLER CAN SUPPLY} = 300 \times 12000 = 3.6 \text{ MMBtu/h}$$

$$\therefore \text{PERCENT OF LOAD IS} = \frac{3.6 \text{ MMBtu/h}}{9.6 \text{ MMBtu/h}} = 37.5\%$$

$$\text{FROM PL-CUBE BASE RUN, HRS @ } 37.5\% \text{ IS } 1807 \text{ HR.}$$

EXISTING ENERGY USAGE: 150 HP @ 90.23 % EFF

$$KW = \frac{150 \times 0.746}{90.23\%} = 124 \text{ KW}$$

NEW ENERGY USAGE: = 44.1 KW

$$\text{KW SAVING} = 124 - 44.1 = 80 \text{ KW}$$

$$\text{\$ SAVING} = 80 \text{ KW} \times 1807 \text{ HR} \times 0.0137 \text{ \$/kWh} = \$1980 / \text{YR}$$

$$\text{OR} = 144,560 \text{ kWh / YR}$$

$$\text{OR} = 493.4 \text{ MMBtu / YR}$$



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 730EC14

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: PUMP TO MATCH LOAD

ANALYSIS DATE: 04-15-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	12141.
B. SIOH	\$	668.
C. DESIGN COST	\$	729.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	12184.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	12184.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	493.	\$ 1981.	11.37	22519.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		493.	\$ 1981.		\$ 22519.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	0.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	0.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	0.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	7431.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= _____		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 1981.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 22519.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.85  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 6.15

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:**

730

**ENERGY CONSERVATION OPPORTUNITY:**

ECO- 17

**SYSTEM MODIFICATION: DECENTRALIZED BOILERS, ELEC. BOILERS FOR EACH BLDG. DHW  
SYSTEMS TO MODIFY: ELECTRICAL WATER HEATERS**

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-17, install electric boilers for summer DHW.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	43	144,000	1,582	2,073
ECO	164	192,800	0	658
Savings (Baseline-ECO)	(121)	(48,800)	1,582	1,415

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:  $-167 \text{ MMBtu/Yr} \times \$4.0141 / \text{MMBtu} = (\$669) \text{ per year}$

Nat. Gas:  $1582 \text{ MMBtu/Yr} \times \$2.92 / \text{MMBtu} = \$4,619 \text{ per year}$

**Total Energy Cost Savings:**  $(\$669) + \$4,619 = \$3,951 \text{ per year}$

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:  $-121 \text{ kW/month} \times \$1.787 / \text{kW} \times 12 \text{ months/year}$

$= (+) (\$2,595) \text{ per year}$

Maintenance:  $= (-) \$0 \text{ per year}$

**Total:**  $(\$2,595) - \$0 = (\$2,595) \text{ per year}$

[ECO-SHT.WK3]

[illegible]

DA FOR 18--R. APR 85

## PC-CUBE VERSION 2.0.3

## CENTRAL PLANT 730 BASELINE-2

\*\* TOTAL \*\*

## SYSTEM C1 OFF SEASON COOLONG, DOMESTIC HW, AND DISTR. LOSS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	1581.
PEAK DAY GAS CONSUMP., 1000 CU FT	12.
ELECTRICAL CONSUMPTION, KWH	145159.
PEAK KW DEMAND (15 MIN BASIS)	130.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	145159.
ON-PEAK KW DEMAND (15 MIN BASIS)	130.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	768
BOILER OPERATING HOURS	
BOILER 1	1810
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Demand Savings:           43 kW for HW pump  
                           164 kW for Electric boiler  
                   Total    -121 kW net extra demand

## Energy savings(electricity):

Proposed electric boiler consumption -

274 MMBtu/yr DHW load * ( 1 kWh/.003413 MMBtu)	= 80,000 kWh/yr
est. 20 kW aux loads * 1400 hours/yr	= <u>28,000</u> kWh/yr
Total	108,000 kWh/yr

Existing cooling and HW pump energy           145,000 kWh/yr (see above)

Existing HW pumps only energy, 43kW\*1400hrs/yr =   60,200 kWh/yr

Total electrical consumption for ECO 17,

108,000 + 145,000 - 60,200	= 192,800 kWh/yr
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LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B730E3B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ELECTRIC BOILER

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	36427.
B. SIOH	\$	2004.
C. DESIGN COST	\$	2186.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	36555.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	36555.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	-167.	\$ -670.	11.37	-7622.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	1582.	\$ 4619.	17.52	80933.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		1415.	\$ 3949.		\$ 73311.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-2594.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-30220.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-30220.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	24193.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= _____		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(YEARS\ ECONOMIC\ LIFE))$  \$ 1355.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 43091.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.18  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)  $SPB=1F/4$  26.98

**CENTRAL PLANT 914**

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 914  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-3  
**SYSTEM MODIFICATION:** MINOR RENOVATION & ANNUAL MAINTENANCE  
**SYSTEMS TO MODIFY:** CHILLER 1

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-3, renovate or replace existing chillers. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	286	563,000	--	1,922
ECO	193	433,000	--	1,478
Savings (Baseline-ECO)	93	130,000	0	444

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 444 MMBtu/Yr X \$4.0141 /MMBtu = \$1,781 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$1,781 + \$0 = \$1,781 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 93 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$1,994 per year  
 Maintenance: = (-) \$3,000 per year  
**Total: \$1,994 - \$3,000 = (\$1,006) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 914 BASELINE-1

\*\* TOTAL \*\*

SYSTEM C1 COOLING FOR ALL BLDGS AND HEATING FOR BLDG 914

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13338.
PEAK DAY GAS CONSUMP., 1000 CU FT	126.
ELECTRICAL CONSUMPTION, KWH	563059.
PEAK KW DEMAND (15 MIN BASIS)	286.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	563059.
ON-PEAK KW DEMAND (15 MIN BASIS)	286.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2807
BOILER 3	348
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 914 CHILLER ECO-3

\*\* TOTAL \*\*

SYSTEM C1 HTG FOR 914 &amp; CLG W/ CHILLER IMPROVEMENT TO 90% EFF

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13338.
PEAK DAY GAS CONSUMP., 1000 CU FT	126.
ELECTRICAL CONSUMPTION, KWH	434224.
PEAK KW DEMAND (15 MIN BASIS)	190.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	434224.
ON-PEAK KW DEMAND (15 MIN BASIS)	190.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2807
BOILER 3	348
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C914EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000      ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER MAINTENANCE

ANALYSIS DATE: 04-09-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	3000.
B. SIOH	\$	165.
C. DESIGN COST	\$	180.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	3011.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	3011.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	444.	\$ 1781.	8.78	15637.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		444.	\$ 1781.		\$ 15637.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-1006.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-9165.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-9165.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 5160.

    A IF 3D1 IS = OR > 3C GO TO ITEM 4

    B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

    C IF 3D1B IS = > 1 GO TO ITEM 4

    D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 775.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 6473.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 2.15  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 3.88

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 914  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	428	0	0	0

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	428 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$9,178		per year
Maintenance:	= (-)		\$0		per year
<b>Total:</b>	<b>\$9,178</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$9,178 per year</b>

# A new application of an old idea that can cut air conditioning energy costs in half.

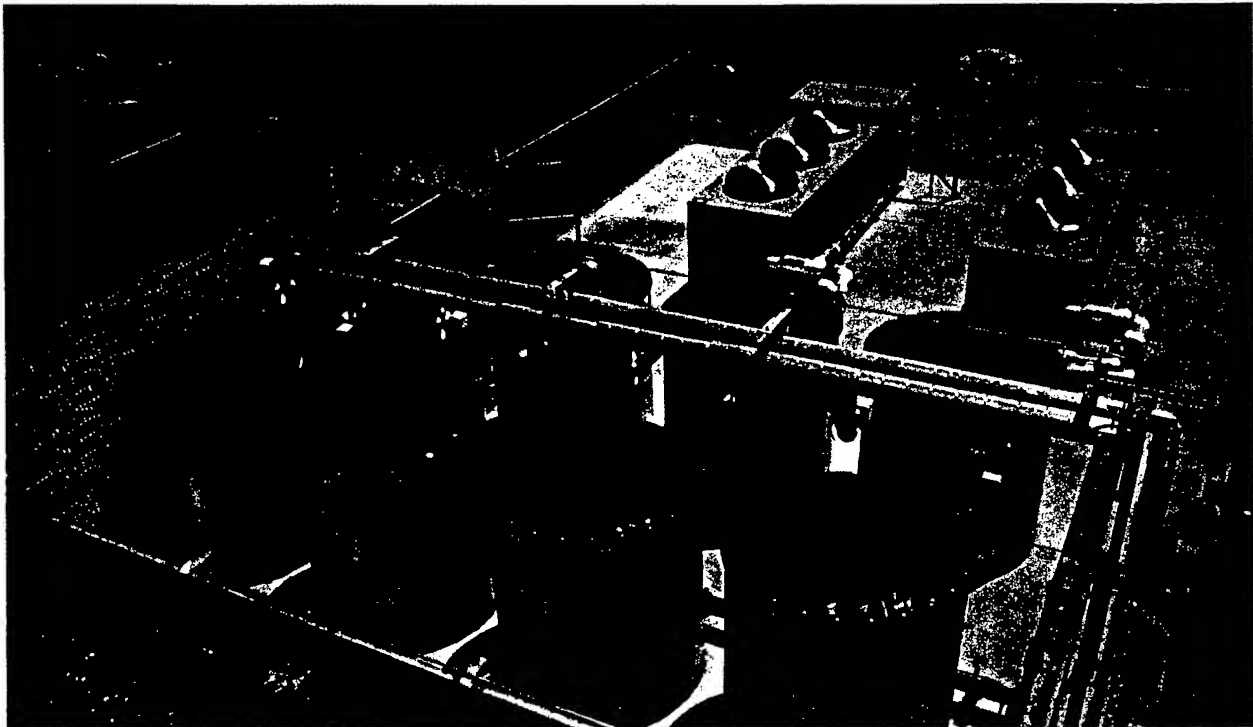
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes—90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.

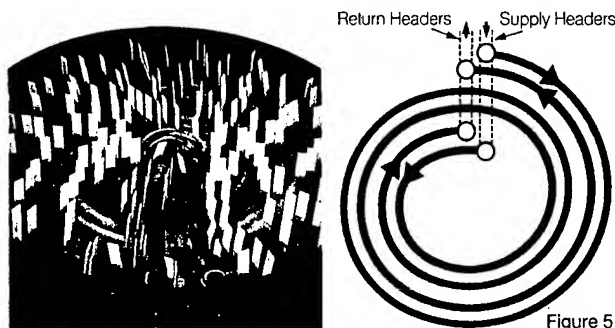


Figure 5

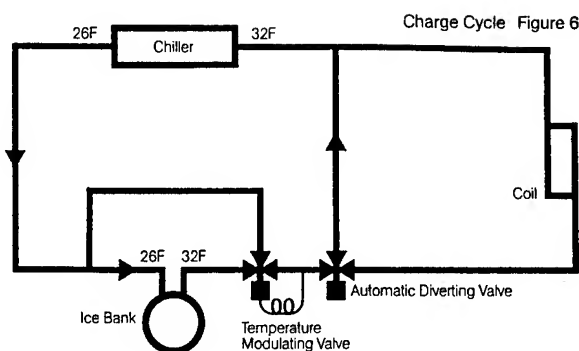
Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

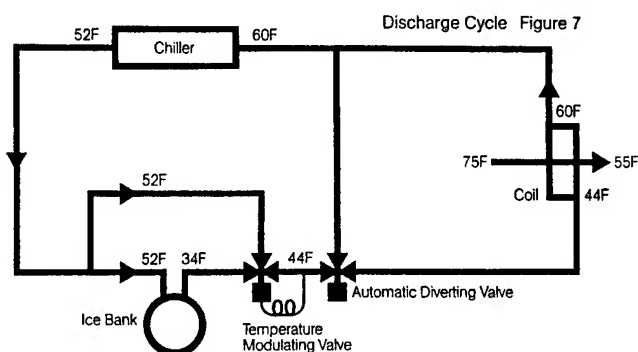
During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.



Charge Cycle Figure 6



Discharge Cycle Figure 7

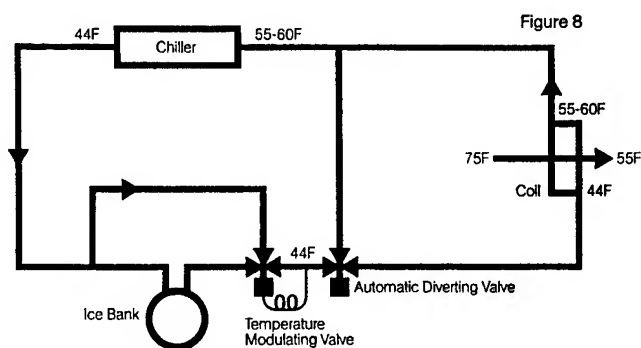


Figure 8

The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's DOWTHERM® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 914EC4  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM  
 ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	96000.
B. SIOH	\$	5280.
C. DESIGN COST	\$	5760.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	96336.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	96336.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	9178.
(1) DISCOUNT FACTOR (TABLE A)	11.65		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	106924.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	106924.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)		\$	0.
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=	.00		
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 9178.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 106924.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.11  
 (IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 10.50

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 914  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	7,148	--	24
ECO	--	4,451	--	15
Savings (Baseline-ECO)	0	2,697	0	9

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	9 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$37 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$37 +</b>	<b>\$0</b>	<b>=</b>	<b>\$37 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$361 per year		
<b>Total:</b>		<b>\$0 -</b>	<b>\$361</b>	<b>=</b>	<b>(\$361) per year</b>

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input. The calculations take into account multi-cell towers (part 7). The control sequence is:

- 0-25% load, fan 1, half speed cycling.
- 25-50% load, fan 1 half speed running, fan 2 half speed cycling:
- 50-75% load, fan 1 full speed cycling, fan 2 half speed running.
- 75-100% load, fan 1 full speed running, fan 2 full speed cycling.

kWh per bin, for % design loads less than 25% load = (fan 1 power kW) \* 14% \* (% design load / 25) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 25% to 50% load = (fan 1 power kW \* 14% \* 4 hours per bin \* days per month) \* (fan 2 power kW \* 14% \* ((% design load - 25) / 25) \* 4 hours per bin \* days per month)

kWh per bin, for % design loads 50% to 75% load = (fan 2 power kW \* 14% \* 4 hours per bin \* days per month) \* (fan 1 power kW \* ((% design load - 50) / 25) \* 4 hours per bin \* days per month)

kWh per bin, for % design loads 75% to 100% load = (fan 1 power kW \* 4 hours per bin \* days per month) + (fan 2 power kW \* ((% design load - 75) / 25) \* 4 hours per bin \* days per month)

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = (total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 914	
DESIGN CONDITIONS	
– WBT (DB, DEG F)	77
– WATER FLOW (gpm)	950
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
– AIR FLOW (LBS/MIN)	3942.5
HEAT REJECTION CAPACITY (Btu/min)	
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	40.57
TOTAL ENTHALPY	60.57
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	59532
MOTOR DATA	
– FAN 1 POWER (kW)	8.6
– FAN 2 POWER (kW)	8.6

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

WET-BULB AVERAGES (4 hour bins)							DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	77
MAY	57.1	56.6	61.2	63.9	63	59.4	77
JUNE	66.8	66.6	69.9	71	70.5	68.2	77
JULY	70.8	70.9	74.5	76	74.9	72.6	77
AUGUST	66.9	67	71	72	71	68.5	77
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	77
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	77

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	40.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	40.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	40.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	40.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	40.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	40.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	40.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD
	1-4	5-8	9-12	13-16	17-20	21-24	(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.7	0.7	0.3	0.3	3240000
JUNE	0.3	0.3	0.7	0.7	0.3	0.3	4468000
JULY	0.3	0.3	0.7	0.7	0.3	0.3	4468000
AUGUST	0.3	0.3	0.7	0.7	0.3	0.3	4468000
SEPTEMBER	0.3	0.3	0.7	0.7	0.3	0.3	4468000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.8	1.8	1.7	1.6	1.6	1.7	31
JUNE	1.5	1.5	1.3	1.3	1.3	1.4	30
JULY	1.3	1.3	1.1	1.1	1.1	1.2	31
AUGUST	1.5	1.4	1.3	1.2	1.3	1.4	31
SEPTEMBER	1.5	1.5	1.4	1.4	1.4	1.5	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

% DESIGN LOAD							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	12.1	12.0	30.5	32.4	13.6	12.6	31
JUNE	20.6	20.5	52.7	54.6	23.0	21.4	30
JULY	23.3	23.3	62.4	66.7	27.2	24.8	31
AUGUST	20.7	20.7	54.6	56.6	23.4	21.6	31
SEPTEMBER	19.7	19.6	49.4	50.9	20.9	20.0	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

TWO SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	72	71	182	193	81	75	
JUNE	119	119	401	481	133	124	
JULY	139	139	828	1010	162	148	
AUGUST	123	124	497	580	140	129	
SEPTEMBER	114	113	286	328	121	115	
OCTOBER	0	0	0	0	0	0	
TOTAL	567	566	2194	2591	638	592	7148

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	5	5	76	91	7	5	
JUNE	23	22	378	421	31	25	
JULY	34	34	648	790	54	41	
AUGUST	24	24	435	483	34	27	
SEPTEMBER	20	19	312	341	24	21	
OCTOBER	0	0	0	0	0	0	
TOTAL	104	104	1848	2126	150	119	4451

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 914EC5B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91 ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	6021.
B. SIOH	\$	332.
C. DESIGN COST	\$	362.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	6044.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	6044.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	9.	\$ 37.	11.37	420.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		9.	\$ 37.		\$ 420.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      11.65

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -4206.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -4206.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 139.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -324.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -3786.

6. DISCOUNTED SAVINGS RATIO      (SIR)=(5 / 1F)= -0.63

(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)      SPB=1F/4      -18.65

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 914  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.  
 It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	5	8,932	0	30

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	30 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$122 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$122</b>	<b>+</b>	<b>\$0</b>	<b>=</b>	<b>\$122 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	5 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$107 per year
Maintenance:	=	(-)			\$0 per year
<b>Total:</b>	<b>\$107</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$107 per year</b>

[ECO-SHT.WK3]

## HIGH EFFICIENCY MOTOR REPLACEMENT

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR
730	CWP-1	150.0	179.0	147.0	0.87	460	90.19%	95.00%	5.73	2641	15120	\$330
	CWP-2	150.0	179.0	148.0	0.91	460	86.22%	95.00%	11.50	1873	21539	\$542
	CNWP-1	50.0	118.0	107.0	0.98	230	80.97%	93.00%	6.67	2641	17629	\$385
	CNWP-2	50.0	118.0	107.0	0.99	230	80.15%	93.00%	7.27	468	3405	\$203
	CNWP-3	NI	NI	NI								
	CTM-1	30.0	71.4	70.7	0.93	230	84.60%	92.40%	2.61	702	1834	\$81
	CTM-2	30.0	71.4	71.0	0.87	230	90.44%	92.40%	0.58	702	405	\$18
	HWP-1	50.0	125.0	117.5	0.87	230	86.10%	93.00%	3.51	3624	12722	\$250
	HWP-2	50.0	125.0	118.0	0.87	230	86.10%	93.00%	3.53	3624	12776	\$251
DEMAND CREDIT				\$888	MMBtu	292		TOTAL	41		85430	\$2,058
914	CWP-1	40.0	48.0	41.3	0.87	460	89.69%	93.00%	1.14	3672	4178	\$82
	CNWP-1	15.0	19.0	14.4	0.82	460	90.15%	90.20%	0.01	3672	23	\$0
	CTM-1	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	CTM-2	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	HWP-1	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33
	HWP-2	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34
DEMAND CREDIT				\$111	MMBtu	30		TOTAL	5		8932	\$233
2812	CWP-1	20.0	27.0	23.0	0.77	460	90.07%	91.00%	0.16	3672	586	\$11
	CNWP-1	25.0	31.5	26.5	0.82	460	91.18%	91.70%	0.11	3672	394	\$8
	CTM-1	15.0	18.6	18.6	0.87	460	86.79%	90.20%	0.56	1167	655	\$21
	HWP-1	7.5	21.6	18.5	0.87	230	74.74%	88.50%	1.33	5163	6888	\$123
	HWP-2	7.5	21.6	19.0	0.87	230	74.74%	88.50%	1.37	3672	5031	\$98
DEMAND CREDIT				\$76	MMBtu	46		TOTAL	4		13554	\$261
3442	CWP-1	60.0	73.0	63.0	0.84	460	91.62%	94.50%	1.40	3672	5158	\$101
	CWP-2	60.0	73.0	63.4	0.84	460	91.62%	94.50%	1.41	3672	5191	\$101
	CNWP-1	40.0	52.0	41.0	0.78	460	92.34%	93.00%	0.20	3672	721	\$14
	CNWP-2	40.0	52.0	35.8	0.78	460	92.34%	93.00%	0.17	3672	629	\$12
	CTM-1	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-2	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-3	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-4	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
DEMAND CREDIT				\$90	MMBtu	44		TOTAL	4		12880	\$266
4701	CWP-1	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CWP-2	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CNWP-1	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CNWP-2	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CTM-1	20.0	24.6	18.2	0.87	460	87.50%	91.00%	0.55	650	361	\$17
	CTM-2	15.0	19.2	16.5	0.87	440	87.90%	90.20%	0.32	650	206	\$10
DEMAND CREDIT				\$65	MMBtu	16		TOTAL	3		4605	\$128
5676	HCP-1	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	HCP-2	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	10.5	9	0.79	460	84.66%	88.50%	0.29	1160	337	\$11
DEMAND CREDIT				\$94	MMBtu	83		TOTAL	4		24287	\$427
5678	HCP-1	2.0	6.5	5.9	0.83	208	76.76%	84.00%	0.20	7296	1445	\$24
	HCP-2	2.0	6.5	5.7	0.83	208	76.76%	84.00%	0.19	7296	1396	\$23
	HCP-3	1.5	4.8	4.5	0.83	230	70.51%	84.00%	0.34	7296	2474	\$41
	HCP-4	2.0	6.3	5.8	0.83	230	71.62%	84.00%	0.39	7296	2878	\$48
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	11	9.6	0.75	460	85.12%	88.50%	0.26	1139	293	\$10
DEMAND CREDIT				\$64	MMBtu	49		TOTAL	3		14412	\$262



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 914EC6

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	8937.
B. SIOH	\$	492.
C. DESIGN COST	\$	537.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	8969.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	8969.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	31.	\$ 122.	11.37	1392.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		31.	\$ 122.		\$ 1392.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	107.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	1247.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	1247.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	459.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		.21
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 229.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 2639.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .29  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 39.09

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 914  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-7  
**SYSTEM MODIFICATION:** INSTALL INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-7, install instrumentation to facilitate efficient operation of boiler plant. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	0	11	11

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	11 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$32 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$32</b>	<b>=</b>	<b>\$32 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$0 per year
Maintenance:	=	(-)			\$320 per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$320</b>	<b>=</b>	<b>(\$320) per year</b>

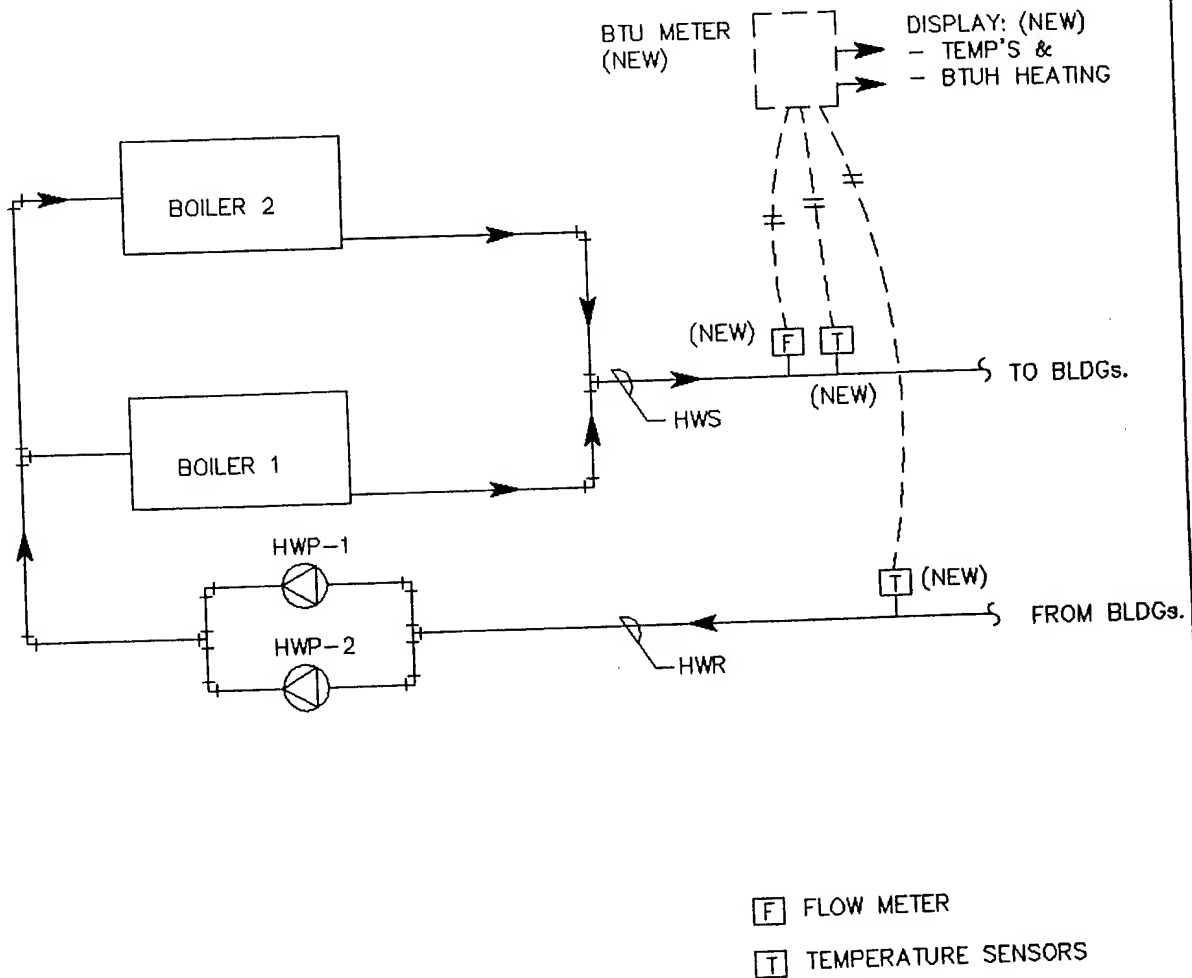
[ECO-SHT.WK3]

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS STANDBY SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0		
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	51.62	\$150.74
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.82	\$160.09
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	\$159.27
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0		
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0		
					TOTAL	8.88		2160	160.99	\$470.10
6003	1	STEAM-12	KEWANE	L39-350-805	11.72	9.41	0.0841	0		
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0		
	3	STEAM-12	KEWANE	L36-350-805	11.72	9.37	0.0837	720	67.45	\$196.96
					TOTAL			720	67.45	\$196.96
730	1	STEAM-12	KEWANE	CAT#7L286-KX	7.75	6.16	0.0616	0		
	2	STEAM-12	KEWANE	CAT#7L286-KX	7.75	6.16	0.0616	720	44.34	\$129.47
	3	STEAM-12	KEWANE	CAT#7L286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANE	CAT#7L280-KG-06	2.66	2.11	0.0211	0		
					TOTAL			1440	88.84	\$259.43
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3582	1.80	1.40	0.0140	0		
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.77	0.0277	0		
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.62	\$60.21
					TOTAL			720	20.62	\$60.21
5676	1	HW	AMERICAN STANDARD	PF 515	2.44	1.80	0.0180	720	12.93	\$37.76
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
					TOTAL			720	12.93	\$37.76
5678	1	HW	BRUNHAM	PF 514	2.27	1.50	0.0150	720	10.79	\$31.50
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
					TOTAL			720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.81	1.29	0.0129	0		
	2	HW	RAY-PAK	EA 2001TB	1.61	1.22	0.0122	0		
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0		
					TOTAL			720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	0		
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
					TOTAL			720	60.73	\$177.33

[BOILERS.WK3]

# ECO-7, INSTRUMENTATION FOR BOILER PLANT (TYPICAL)



[B-ECO-7.DWG]



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B914EC1

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOM      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000      ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER INSTRUMENTATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	5327.
B. SIOH	\$	293.
C. DESIGN COST	\$	320.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5346.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5346.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	11.	\$ 31.	12.48	385.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		11.	\$ 31.		\$ 385.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-320.
(1) DISCOUNT FACTOR (TABLE A)	9.11	
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-2915.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-2915.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	127.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -289.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -2530.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.47  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -18.49

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 914  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-8  
**SYSTEM MODIFICATION:** BOILER OPTIMIZATION, CONTROL & INSTRUMENTATION  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-8, install instrumentation connected to EMCS for boiler optimization. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	13,338	13,338
ECO	--	--	13,294	13,294
Savings (Baseline-ECO)	0	0	44	44

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	44 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$128 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$128</b>	<b>=</b>	<b>\$128 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0		per year
Maintenance:	= (-)		\$2,031		per year
<b>Total:</b>		<b>\$0 -</b>	<b>\$2,031</b>	<b>=</b>	<b>(\$2,031) per year</b>

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 914 BASELINE-1

\*\* TOTAL \*\*

SYSTEM C1 COOLING FOR ALL BLDGS AND HEATING FOR BLDG 914

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13338.
PEAK DAY GAS CONSUMP., 1000 CU FT	126.
ELECTRICAL CONSUMPTION, KWH	563059.
PEAK KW DEMAND (15 MIN BASIS)	286.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	563059.
ON-PEAK KW DEMAND (15 MIN BASIS)	286.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2807
BOILER 3	348
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

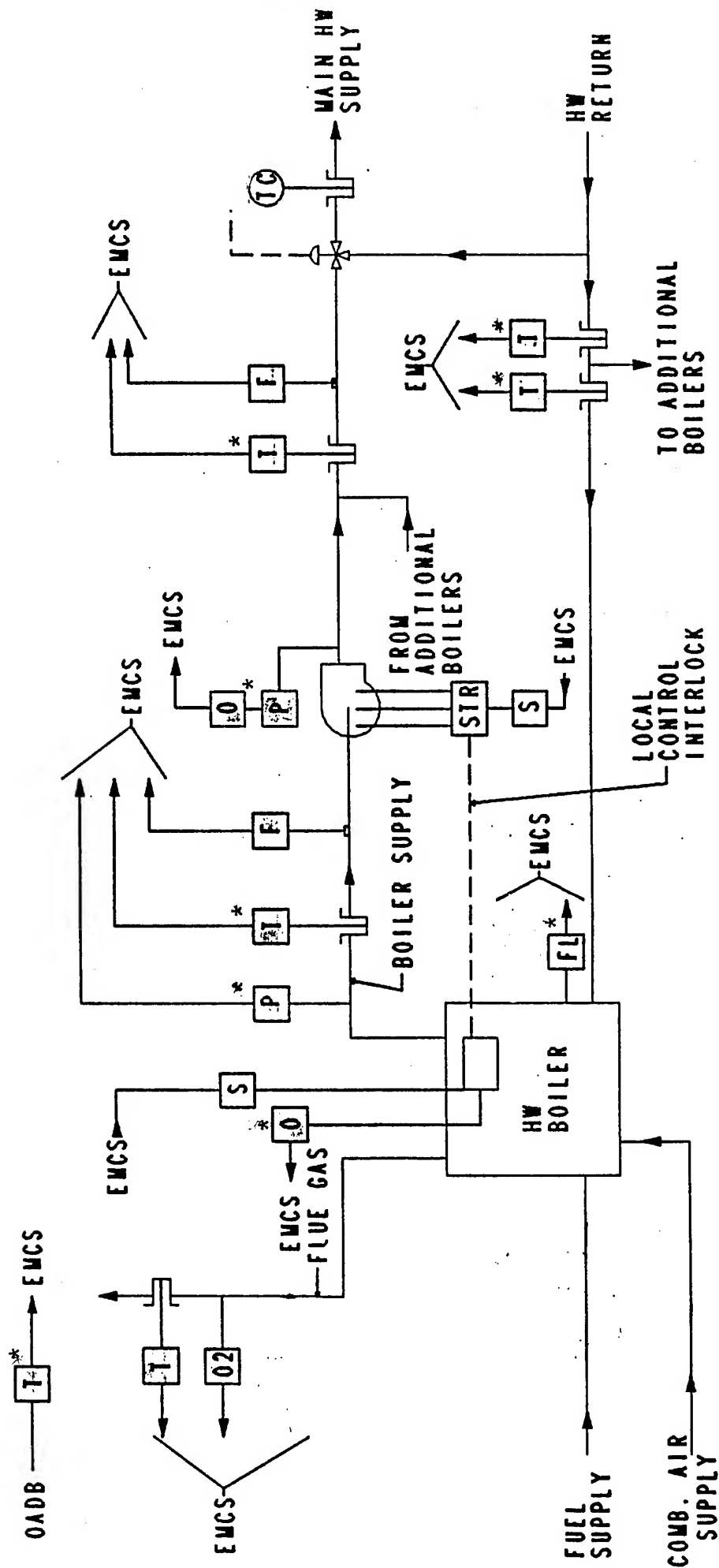
PC-CUBE VERSION 2.0.3

CENTRAL PLANT 914 BOILER ECO-8

\*\* TOTAL \*\*

SYSTEM C1 COOLING FOR ALL BLDGS AND HEATING FOR BLDG 914



FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13293.
PEAK DAY GAS CONSUMP., 1000 CU FT	125.
ELECTRICAL CONSUMPTION, KWH	563059.
PEAK KW DEMAND (15 MIN BASIS)	286.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	563059.
ON-PEAK KW DEMAND (15 MIN BASIS)	286.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2807
BOILER 3	1398
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



Hot water boiler

\* - Points included on proposed EMCS design, existing.  
All other points are new.

→	EMCS	SIGNAL TRANSMITTED TO EMCS
←	EMCS	SIGNAL TRANSMITTED FROM EMCS
[A]	ALARM	CONTACT SIGNAL
[E]	ECONOMIZER	CONTROL INTERFACE
[F]	FLOW	INDICATION
[FL]	FLAME	INDICATION
[H]	HUMIDITY	INDICATION
[P]	PRESSURE	INDICATION
[LV]	LEVEL	INDICATION
[M]	METER	
[O]	ON-OFF	STATUS SIGNAL
[DP]	DIFFERENTIAL	PRESSURE SWITCH
[R]	CONTROLLER	RESET INTERFACE
[S]	START-STOP	INTERFACE
[T]	TEMPERATURE	INDICATION
[V]	VENTILATION/RECIRCULATION	CONTROL
[PS]	POSITION	
[O <sub>2</sub> ]	FLUE GAS ANALYSIS,	OXYGEN
[C <sub>o</sub> ]	FLUE GAS ANALYSIS,	CARBON MONOXIDE

[FD]	FURNACE DRAFT DIFFERENTIAL PRESSURE
[DS]	HIGH-LOW DEMAND SIGNAL SELECTOR
[TC]	TEMPERATURE CONTROLLER
[PC]	PRESSURE CONTROLLER
[STR]	MOTOR STARTER
	SENSOR INSTALLED IN THERMOMETER WELL
	SENSOR INSTALLED IN DUCT OR PLENUM
CHW	CHILLED WATER
EA	EXHAUST AIR
SA	SUPPLY AIR
RA	RETURN AIR
OA	OUTSIDE AIR
MA	MIXED AIR
WB	WET BULB
DB	DRY BULB
OAD	OUTSIDE AIR DAMPER
RAD	RETURN AIR DAMPER
EAD	EXHAUST AIR DAMPER
MZD	MULTIZONE DAMPER
RH	RELATIVE HUMIDITY

Symbols and Abbreviations



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: B914EC12  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER OPTIMIZATION  
 ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	33847.
B. SIOH	\$	1862.
C. DESIGN COST	\$	2031.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	33966.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	33966.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	44.	\$ 128.	12.48	1603.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		44.	\$ 128.		\$ 1603.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -18502.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -18502.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 529.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -1903.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -16899.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -1.50  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -17.85

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 914  
**ENERGY CONSERVATION OPPORTUNITY:**  
**SYSTEM MODIFICATION:** RENOVATE BOILERS  
**SYSTEMS TO MODIFY:** BOILER 2, 3, AND 4

ECO- 9

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-9, renovate or replace existing boilers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	13,338	13,338
ECO	--	--	12,838	12,838
Savings (Baseline-ECO)	0	0	500	500

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	500 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$1,460 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$1,460</b>	<b>=</b>	<b>\$1,460 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$3,000 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$3,000</b>	<b>=</b>	<b>(\$3,000) per year</b>

[ECO-SHT.WK3]

## CENTRAL PLANT 914 BASELINE-1

## SYSTEM C1 COOLING FOR ALL BLDGS AND HEATING FOR BLDG 914

\*\* TOTAL \*\*

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13338.
PEAK DAY GAS CONSUMP., 1000 CU FT	126.
ELECTRICAL CONSUMPTION, KWH	563059.
PEAK KW DEMAND (15 MIN BASIS)	286.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	563059.
ON-PEAK KW DEMAND (15 MIN BASIS)	286.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2807
BOILER 3	348
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 914 BOILER ECO-9

\*\* TOTAL \*\*

SYSTEM C1 COOLING FOR ALL BLDGS AND HEATING FOR BLDG 914

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	12837.
PEAK DAY GAS CONSUMP., 1000 CU FT	121.
ELECTRICAL CONSUMPTION, KWH	563059.
PEAK KW DEMAND (15 MIN BASIS)	286.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	563059.
ON-PEAK KW DEMAND (15 MIN BASIS)	286.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2785
BOILER 3	256
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B914EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER RENOVATION

ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	18035.
B. SIOH	\$	992.
C. DESIGN COST	\$	1082.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	18098.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	18098.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	500.	\$ 1460.	17.52	25579.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		500.	\$ 1460.		\$ 25579.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-3000.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-34950.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-34950.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	8441.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -1540.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -9371.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -0.52  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -11.75

**CENTRAL PLANT 2812**

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-3  
**SYSTEM MODIFICATION:** REPLACE EXISTING CHILLER  
**SYSTEMS TO MODIFY:** CHILLER 1

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-3, renovate or replace existing chillers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	192	480,000	--	1,638
ECO	150	408,000	--	1,393
Savings (Baseline-ECO)	42	72,000	0	246

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 246 MMBtu/Yr X \$4.0141 /MMBtu = \$986 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$986 + \$0 = \$986 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 42 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$901 per year  
 Maintenance: = (-) \$3,000 per year  
 Total: \$901 - \$3,000 = (\$2,099) per year

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 BASELINE-1

\*\* TOTAL \*\*

SYSTEM C1 HEATING, COOLING, DOMESTIC HW, AND DIST. LOSS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	27450.
PEAK DAY GAS CONSUMP., 1000 CU FT	237.
ELECTRICAL CONSUMPTION, KWH	479788.
PEAK KW DEMAND (15 MIN BASIS)	192.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	479788.
ON-PEAK KW DEMAND (15 MIN BASIS)	192.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3027
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 CHILLER ECO-3

\*\* TOTAL \*\*

SYSTEM C1 HEATING, COOLING, DOMESTIC HW, AND DIST. LOSS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	27450.
PEAK DAY GAS CONSUMP., 1000 CU FT	237.
ELECTRICAL CONSUMPTION, KWH	407782.
PEAK KW DEMAND (15 MIN BASIS)	150.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	407782.
ON-PEAK KW DEMAND (15 MIN BASIS)	150.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3027
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C2812EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER REPLACEMENT

ANALYSIS DATE: 04-09-91 ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	89947.
B. SIOH	\$	4947.
C. DESIGN COST	\$	5397.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	90262.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	90262.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	246.	\$ 986.	11.37	11216.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		246.	\$ 986.		\$ 11216.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-2099.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-24453.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-24453.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	3701.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -1113.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -13238.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -0.15  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -81.13

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	301	0	0	0

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	301 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$6,455		per year
Maintenance:	= (-)		\$0		per year
<b>Total:</b>	<b>\$6,455</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$6,455 per year</b>

[ECO-SHT.WK3]

# A new application of an old idea that can cut air conditioning energy costs in half.

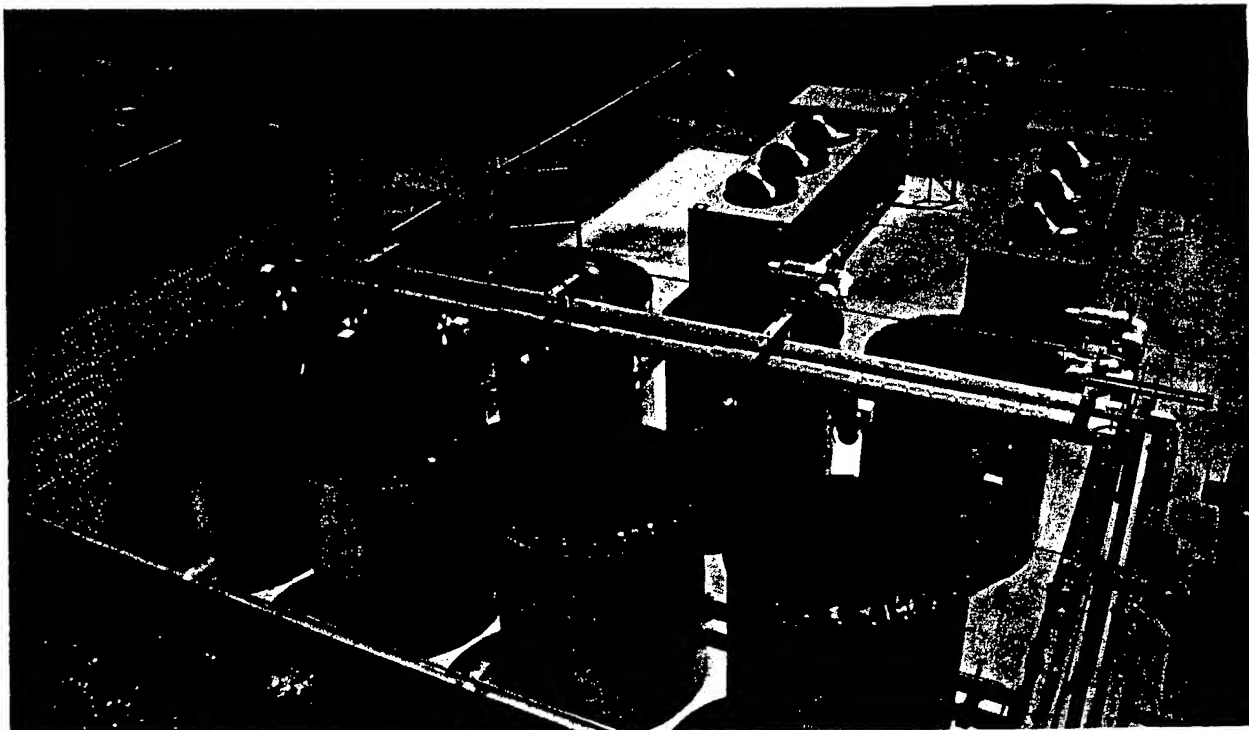
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

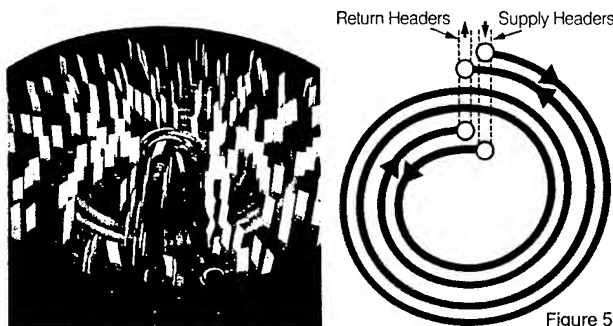
Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes - 90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.



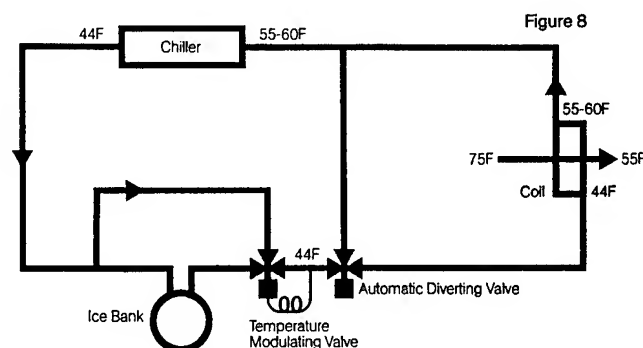
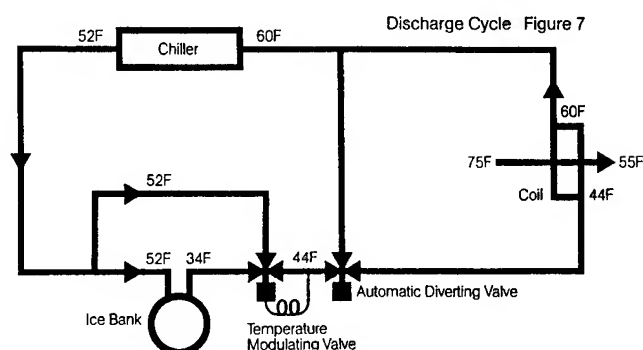
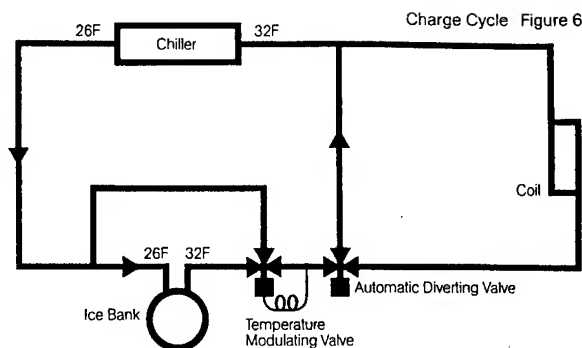
Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.



The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's Dowtherm® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 2812EC4

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM

ANALYSIS DATE: 04-18-91 ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	89280.
B. SIOH	\$	4911.
C. DESIGN COST	\$	5357.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	89593.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	89593.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	6455.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	75201.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	75201.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	0.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=	.00	
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 6455.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 75201.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .84  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 13.88

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(A)  
**SYSTEM MODIFICATION:** TWO SPEED FANS FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	17,273	--	59
ECO	--	8,713	--	30
Savings (Baseline-ECO)	0	8,560	0	29

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	29 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$117 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$117 +</b>	<b>\$0</b>	<b>=</b>	<b>\$117 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

$(\text{Total exit air design enthalpy minus average monthly enthalpy, part 2}) / (\text{entering air design enthalpy})$

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

$(\% \text{ load on plant, part 3} * \text{monthly peak load, part 3}) / (\text{Highest monthly peak load, part 3}) * (1 / \text{ratio of monthly enthalpy, part 4})$

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

$\text{kWh per bin} = (\text{total fan power kW}) * (\% \text{ design load, part 5} * 4 \text{ hours per bin} * \text{days per month})$

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input (part 7). The control sequence is:

- 0-50% load, fan 1, half speed cycling.
- 50-100% load, fan 1 full speed cycling.

kWh per bin, for % design loads less than 50% load = (fan 1 power kW) \* 14% \* (% design load / 50) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 50% to 100% load = ( fan 1 power kW \* ((% design load)/ 100) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

<b>CENTRAL PLANT</b>		<b>2812</b>
<b>DESIGN CONDITIONS</b>		
– WBT (DB, DEG F)		76
– WATER FLOW (gpm)		2600
– CNWR (DEG F)		95
– CNWS (DEG F)		85
ASSUMPTION LIQUID TO GAS RATIO		2
– AIR FLOW (LBS/MIN)		10790
HEAT REJECTION CAPACITY (Btu/min)		215800
DELTA ENTHALPY (Btu/lb)		20
DESIGN ENTHALPY (Btu/lb)		39.57
TOTAL ENTHALPY		59.57
EXIT AIR WB (LOOK UP)		93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)		15.1
100% DESIGN CFM @ WB		162929
<b>MOTOR DATA</b>		
– FAN 1 POWER (kW)		11.8
– FAN 2 POWER (kW)		0

**ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA**

	WET – BULB AVERAGES						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	76
MAY	57.1	56.6	61.2	63.9	63	59.4	76
JUNE	66.8	66.6	69.9	71	70.5	68.2	76
JULY	70.8	70.9	74.5	76	74.9	72.6	76
AUGUST	66.9	67	71	72	71	68.5	76
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	76
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	76

	ENTHALPY FOR AVERAGE WET – BULBS						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	39.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	39.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	39.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	39.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	39.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	39.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	39.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD (Btuh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.5	0.7	0.9	0.5	3740000
JUNE	0.3	0.3	0.5	0.7	0.9	0.5	4365000
JULY	0.3	0.3	0.5	0.7	0.9	0.5	4392000
AUGUST	0.3	0.3	0.5	0.7	0.9	0.5	4391000
SEPTEMBER	0.3	0.3	0.5	0.7	0.9	0.5	4329000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	2.0	2.0	1.9	1.8	1.8	1.9	30
MAY	1.8	1.8	1.6	1.5	1.6	1.7	31
JUNE	1.4	1.4	1.3	1.2	1.3	1.3	30
JULY	1.2	1.2	1.1	1.0	1.1	1.2	31
AUGUST	1.4	1.4	1.2	1.2	1.2	1.3	31
SEPTEMBER	1.5	1.5	1.4	1.3	1.4	1.5	30
OCTOBER	1.9	2.0	1.8	1.7	1.8	1.9	31

% DESIGN LOAD							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	14.6	14.5	26.5	39.5	49.8	25.6	31
JUNE	21.4	21.2	39.1	56.9	71.8	37.1	30
JULY	24.3	24.4	47.0	70.4	86.0	43.4	31
AUGUST	21.5	21.6	40.9	59.3	73.5	37.6	31
SEPTEMBER	20.2	20.1	36.3	52.4	64.6	34.1	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

SINGLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	213	213	388	579	728	374	
JUNE	302	301	554	805	1017	525	
JULY	356	357	687	1031	1259	635	
AUGUST	315	316	598	868	1076	551	
SEPTEMBER	286	285	514	742	915	483	
OCTOBER	0	0	0	0	0	0	
TOTAL	1473	1472	2741	4025	4995	2568	17273

TWO SPEED COOLING TOWER CYCLING (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	60	60	109	162	204	105	
JUNE	85	84	310	393	816	147	
JULY	100	100	385	803	1260	178	
AUGUST	88	88	335	478	894	154	
SEPTEMBER	80	80	144	267	611	135	
OCTOBER	0	0	0	0	0	0	
TOTAL	412	412	1282	2102	3785	719	8713

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	6	6	34	113	225	31	
JUNE	17	17	106	325	656	90	
JULY	26	27	189	639	1165	149	
AUGUST	18	18	125	382	728	97	
SEPTEMBER	15	14	85	255	477	70	
OCTOBER	0	0	0	0	0	0	
TOTAL	82	82	539	1715	3251	438	6106



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 2812EC5A

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	6708.
B. SIOH	\$	369.
C. DESIGN COST	\$	403.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	6732.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	6732.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	29.	\$ 117.	11.37	1334.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		29.	\$ 117.		\$ 1334.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	0.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	0.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	0.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	440.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 117.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 1334.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .20  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 57.40

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	17,273	--	59
ECO	--	6,106	--	21
Savings (Baseline-ECO)	0	11,167	0	38

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	38 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$153 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$153 +</b>	<b>\$0</b>	<b>=</b>	<b>\$153 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$0 per year
Maintenance:	=	(-)			\$298 per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$298</b>	<b>=</b>	<b>(\$298) per year</b>

[ECO-SHT.WK3]

## Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input (part 7). The control sequence is:

- 0-50% load, fan 1, half speed cycling.
- 50-100% load, fan 1 full speed cycling.

kWh per bin, for % design loads less than 50% load = (fan 1 power kW) \* 14% \* (%design load / 50) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 50% to 100% load = ( fan 1 power kW \* ((% design load)/ 100) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 2812	
DESIGN CONDITIONS	
– WBT (DB, DEG F)	76
– WATER FLOW (gpm)	2600
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
– AIR FLOW (LBS/MIN)	10790
HEAT REJECTION CAPACITY (Btu/min)	
	215800
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	39.57
TOTAL ENTHALPY	59.57
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	162929
MOTOR DATA	
– FAN 1 POWER (kW)	11.8
– FAN 2 POWER (kW)	0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

WET-BULB AVERAGES							DESIGN WB
	1–4	5–8	9–12	13–16	17–20	21–24	
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	76
MAY	57.1	56.6	61.2	63.9	63	59.4	76
JUNE	66.8	66.6	69.9	71	70.5	68.2	76
JULY	70.8	70.9	74.5	76	74.9	72.6	76
AUGUST	66.9	67	71	72	71	68.5	76
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	76
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	76

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN ENTHALPY
	1–4	5–8	9–12	13–16	17–20	21–24	
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	39.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	39.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	39.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	39.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	39.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	39.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	39.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD
	1-4	5-8	9-12	13-16	17-20	21-24	(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.5	0.7	0.9	0.5	3740000
JUNE	0.3	0.3	0.5	0.7	0.9	0.5	4365000
JULY	0.3	0.3	0.5	0.7	0.9	0.5	4392000
AUGUST	0.3	0.3	0.5	0.7	0.9	0.5	4391000
SEPTEMBER	0.3	0.3	0.5	0.7	0.9	0.5	4329000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	2.0	2.0	1.9	1.8	1.8	1.9	30
MAY	1.8	1.8	1.6	1.5	1.6	1.7	31
JUNE	1.4	1.4	1.3	1.2	1.3	1.3	30
JULY	1.2	1.2	1.1	1.0	1.1	1.2	31
AUGUST	1.4	1.4	1.2	1.2	1.2	1.3	31
SEPTEMBER	1.5	1.5	1.4	1.3	1.4	1.5	30
OCTOBER	1.9	2.0	1.8	1.7	1.8	1.9	31

% DESIGN LOAD							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	14.6	14.5	26.5	39.5	49.8	25.6	31
JUNE	21.4	21.2	39.1	56.9	71.8	37.1	30
JULY	24.3	24.4	47.0	70.4	86.0	43.4	31
AUGUST	21.5	21.6	40.9	59.3	73.5	37.6	31
SEPTEMBER	20.2	20.1	36.3	52.4	64.6	34.1	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

SINGLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	213	213	388	579	728	374	
JUNE	302	301	554	805	1017	525	
JULY	356	357	687	1031	1259	635	
AUGUST	315	316	598	868	1076	551	
SEPTEMBER	286	285	514	742	915	483	
OCTOBER	0	0	0	0	0	0	
TOTAL	1473	1472	2741	4025	4995	2568	17273

TWO SPEED COOLING TOWER CYCLING (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	60	60	109	162	204	105	
JUNE	85	84	310	393	816	147	
JULY	100	100	385	803	1260	178	
AUGUST	88	88	335	478	894	154	
SEPTEMBER	80	80	144	267	611	135	
OCTOBER	0	0	0	0	0	0	
TOTAL	412	412	1282	2102	3785	719	8713

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	6	6	34	113	225	31	
JUNE	17	17	106	325	656	90	
JULY	26	27	189	639	1165	149	
AUGUST	18	18	125	382	728	97	
SEPTEMBER	15	14	85	255	477	70	
OCTOBER	0	0	0	0	0	0	
TOTAL	82	82	539	1715	3251	438	6106



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 2812EC5B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000      ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	4963.
B. SIOH	\$	273.
C. DESIGN COST	\$	298.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	4981.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	4981.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	38.	\$ 153.	11.37	1739.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		38.	\$ 153.		\$ 1739.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      11.65

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -3472.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -3472.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 574.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -145.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -1732.

6. DISCOUNTED SAVINGS RATIO      (SIR)=(5 / 1F)= - .35

(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)      SPB=1F/4      -34.34

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.

It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	4	18,353	0	63

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	63 MMBtu/Yr	X	\$4.0141 /MMBtu =	\$251 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu =	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$251 +</b>	<b>\$0</b>	<b>=</b>	<b>\$251 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	4 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$86 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$86</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$86 per year</b>

[ECO-SHT.WK3]

## HIGH EFFICIENCY MOTOR REPLACEMENT

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR
730	CWP-1	150.0	179.0	147.0	0.87	460	90.19%	95.00%	5.73	2641	15120	\$330
	CWP-2	150.0	179.0	148.0	0.91	460	86.22%	95.00%	11.50	1873	21539	\$542
	CNWP-1	50.0	118.0	107.0	0.98	230	80.97%	93.00%	6.67	2641	17629	\$385
	CNWP-2	50.0	118.0	107.0	0.99	230	80.15%	93.00%	7.27	468	3405	\$203
	CNWP-3	NI	NI	NI								
	CTM-1	30.0	71.4	70.7	0.93	230	84.60%	92.40%	2.61	702	1834	\$81
	CTM-2	30.0	71.4	71.0	0.87	230	90.44%	92.40%	0.58	702	405	\$18
	HWP-1	50.0	125.0	117.5	0.87	230	86.10%	93.00%	3.51	3624	12722	\$250
	HWP-2	50.0	125.0	118.0	0.87	230	86.10%	93.00%	3.53	3624	12776	\$251
	DEMAND CREDIT			\$888	MMBtu	292		TOTAL	41		85430	\$2,058
914	CWP-1	40.0	48.0	41.3	0.87	460	89.69%	93.00%	1.14	3672	4178	\$82
	CNWP-1	15.0	19.0	14.4	0.82	460	90.15%	90.20%	0.01	3672	23	\$0
	CTM-1	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	CTM-2	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	HWP-1	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33
	HWP-2	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34
	DEMAND CREDIT			\$111	MMBtu	30		TOTAL	5		8932	\$233
2812	CWP-1	20.0	27.0	23.0	0.77	460	90.07%	91.00%	0.16	3672	586	\$11
	CNWP-1	25.0	31.5	26.5	0.82	460	91.18%	91.70%	0.11	3672	394	\$8
	CTM-1	15.0	18.6	18.6	0.87	460	86.79%	90.20%	0.56	1167	655	\$21
	HWP-1	7.5	21.6	18.5	0.87	230	74.74%	88.50%	1.33	8760	11687	\$189
	HWP-2	7.5	21.6	19.0	0.87	230	74.74%	88.50%	1.37	3672	5031	\$98
	DEMAND CREDIT			\$76	MMBtu	63		TOTAL	4		18353	\$327
3442	CWP-1	60.0	73.0	63.0	0.84	460	91.62%	94.50%	1.40	3672	5158	\$101
	CWP-2	60.0	73.0	63.4	0.84	460	91.62%	94.50%	1.41	3672	5191	\$101
	CNWP-1	40.0	52.0	41.0	0.78	460	92.34%	93.00%	0.20	3672	721	\$14
	CNWP-2	40.0	52.0	35.8	0.78	460	92.34%	93.00%	0.17	3672	629	\$12
	CTM-1	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-2	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-3	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-4	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	DEMAND CREDIT			\$90	MMBtu	44		TOTAL	4		12880	\$266
4701	CWP-1	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CWP-2	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CNWP-1	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CNWP-2	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CTM-1	20.0	24.6	18.2	0.87	460	87.50%	91.00%	0.55	650	361	\$17
	CTM-2	15.0	19.2	16.5	0.87	440	87.90%	90.20%	0.32	650	206	\$10
	DEMAND CREDIT			\$65	MMBtu	16		TOTAL	3		4605	\$128
5676	HCP-1	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	HCP-2	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	10.5	9	0.79	460	84.66%	88.50%	0.29	1160	337	\$11
DEMAND CREDIT				\$94	MMBtu	83		TOTAL	4		24287	\$427
5678	HCP-1	2.0	6.5	5.9	0.83	208	76.76%	84.00%	0.20	7296	1445	\$24
	HCP-2	2.0	6.5	5.7	0.83	208	76.76%	84.00%	0.19	7296	1396	\$23
	HCP-3	1.5	4.8	4.5	0.83	230	70.51%	84.00%	0.34	7296	2474	\$41
	HCP-4	2.0	6.3	5.8	0.83	230	71.62%	84.00%	0.39	7296	2878	\$48
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	11	9.6	0.75	460	85.12%	88.50%	0.26	1139	293	\$10
DEMAND CREDIT				\$64	MMBtu	49		TOTAL	3		14412	\$262



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 2812EC6

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

LOCATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR

ANALYSIS DATE: 04-15-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	7932.
B. SIOH	\$	437.
C. DESIGN COST	\$	476.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	7961.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	7961.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	63.	\$ 251.	11.37	2857.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		63.	\$ 251.		\$ 2857.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	86.
(1) DISCOUNT FACTOR (TABLE A)	11.65	
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	1002.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	1002.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	943.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=	.48	
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 337.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 3859.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .48  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 23.60

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-7  
**SYSTEM MODIFICATION:** INSTALL INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-7, install instrumentation to facilitate efficient operation of boiler plant. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	0	21	21

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	21 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$61 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$61</b>	<b>=</b>	<b>\$61 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0		per year
Maintenance:	= (-)		\$320		per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$320</b>	<b>=</b>	<b>(\$320) per year</b>

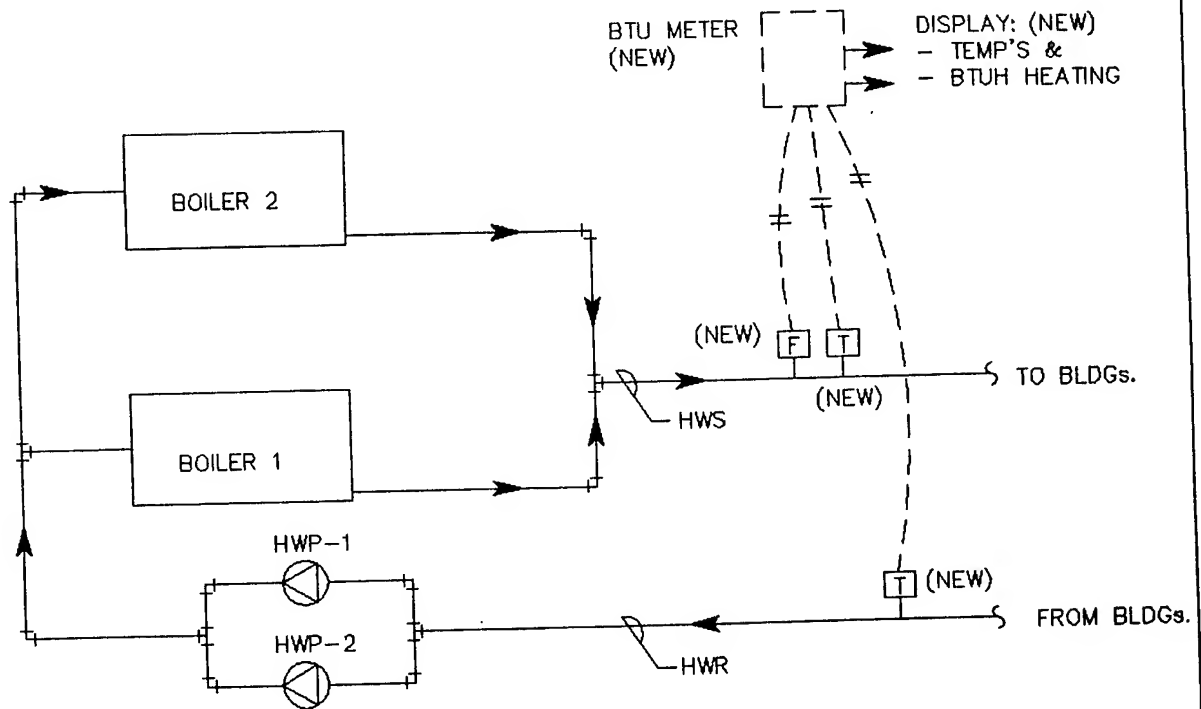
[ECO-SHT.WK3]

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (1%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS STANDBY SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0		
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	51.62	\$150.74
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.82	\$160.09
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	\$159.27
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0		
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0		
TOTAL								2160	160.99	\$470.10
6003	1	STEAM-12	KEWANEE	L39-350-605	11.72	9.41	0.0941	0		
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0		
	3	STEAM-12	KEWANEE	L36-350-605	11.72	9.37	0.0937	720	67.45	\$196.96
TOTAL								720	67.45	\$196.96
730	1	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	0		
	2	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	720	44.34	\$129.47
	3	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANEE	CAT#7L280-KG-06	2.66	2.11	0.0211	0		
TOTAL								1440	88.84	\$259.43
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3562	1.80	1.40	0.0140	0		
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.77	0.0277	0		
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.96	0.0286	720	20.62	\$60.21
TOTAL								720	20.62	\$60.21
5676	1	HW	AMERICAN STANDARD	PF 515	2.44	1.80	0.0180	720	12.93	\$37.76
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
TOTAL								720	12.93	\$37.76
5678	1	HW	BRUNHAM	PF 514	2.27	1.50	0.0150	720	10.79	\$31.50
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
TOTAL								720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.61	1.29	0.0129	0		
	2	HW	RAY-PAK	EA 200ITB	1.61	1.22	0.0122	0		
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0		
TOTAL								720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	0		
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
TOTAL								720	60.73	\$177.33

[BOILERS.WK3]

# ECO-7, INSTRUMENTATION FOR BOILER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[B-ECO-7.DWG]



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B2812E12

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER INSTRUMENTATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	5327.
B. SIOH	\$	293.
C. DESIGN COST	\$	320.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5346.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5346.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	21.	\$ 60.	12.48	751.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		21.	\$ 60.		\$ 751.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -2915.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -2915.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 248.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -260.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -2164.

6. DISCOUNTED SAVINGS RATIO      (SIR)=(5 / 1F)= - .40

(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)      SPB=1F/4      -20.58

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-8  
**SYSTEM MODIFICATION:** BOILER OPTIMIZATION, CONTROL & INSTRUMENTATION  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-8, install instrumentation connected to EMCS for boiler optimization. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	27,451	27,451
ECO	--	--	27,144	27,144
Savings (Baseline-ECO)	0	0	307	307

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 307 MMBtu/Yr X \$2.92 /MMBtu = \$896 per year  
 Total Energy Cost Savings: \$0 + \$896 = \$896 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$1,543 per year  
 Total: \$0 - \$1,543 = (\$1,543) per year

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 BASELINE-1

\*\* TOTAL \*\*

SYSTEM C1 HEATING, COOLING, DOMESTIC HW, AND DIST. LOSS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	27450.
PEAK DAY GAS CONSUMP., 1000 CU FT	237.
ELECTRICAL CONSUMPTION, KWH	479788.
PEAK KW DEMAND (15 MIN BASIS)	192.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	479788.
ON-PEAK KW DEMAND (15 MIN BASIS)	192.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3027
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

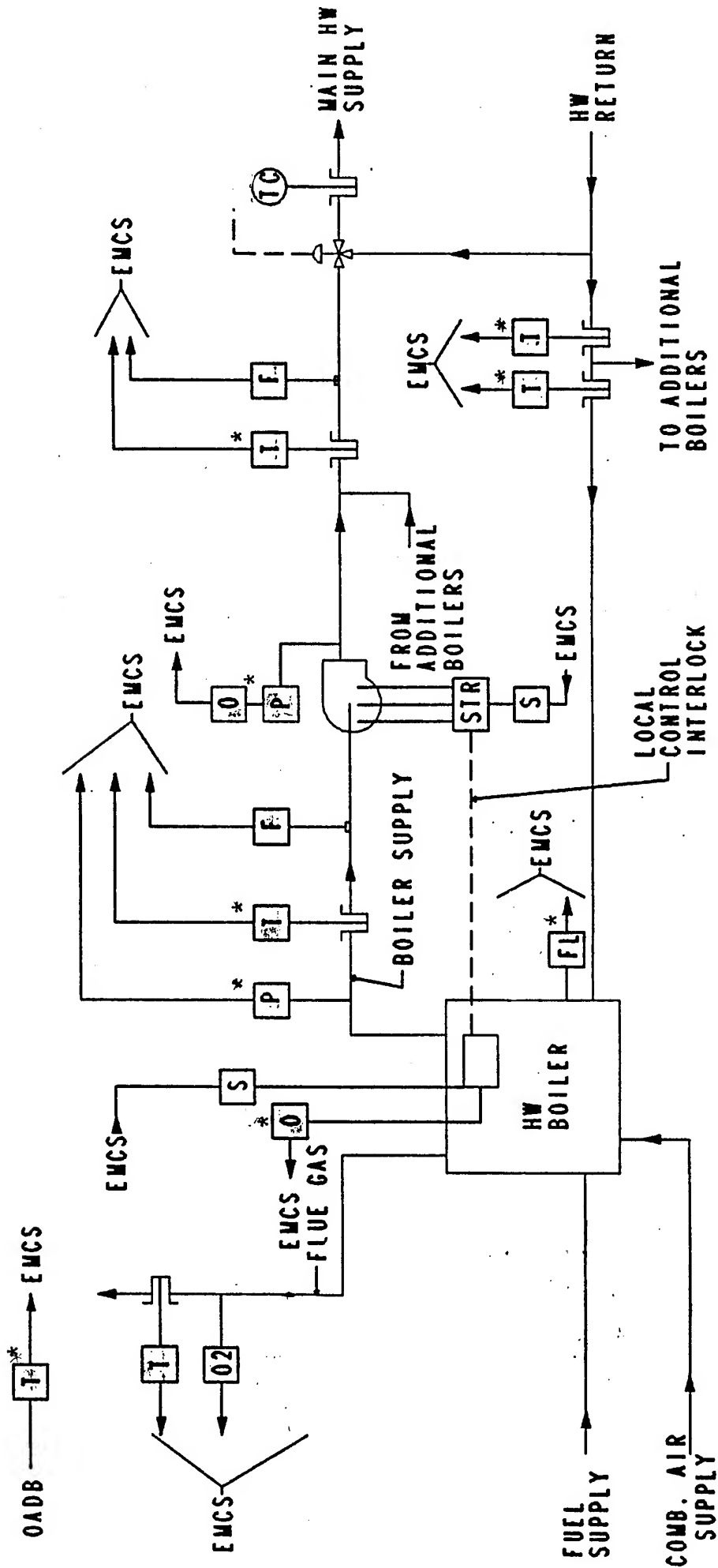
PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 BOILER ECO-2

\*\* TOTAL \*\*

SYSTEM C1 HEATING, COOLING, DOMESTIC HW, AND DIST. LOSS

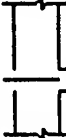

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	27143.
PEAK DAY GAS CONSUMP., 1000 CU FT	237.
ELECTRICAL CONSUMPTION, KWH	469753.
PEAK KW DEMAND (15 MIN BASIS)	192.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	469753.
ON-PEAK KW DEMAND (15 MIN BASIS)	192.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2955
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



# Hot water boiler

\* - Points included on proposed EMCS design, existing.  
All other points are new.

→	EMCS	SIGNAL TRANSMITTED TO EMCS
←	EMCS	SIGNAL TRANSMITTED FROM EMCS
[A]	ALARM CONTACT SIGNAL	
[E]	ECONOMIZER CONTROL INTERFACE	
[F]	FLOW INDICATION	
[FI]	FLAME INDICATION	
[H]	HUMIDITY INDICATION	
[P]	PRESSURE INDICATION	
[LV]	LEVEL INDICATION	
[M]	METER	
[O]	ON-OFF STATUS SIGNAL	
[DP]	DIFFERENTIAL PRESSURE SWITCH	
[R]	CONTROLLER RESET INTERFACE	
[S]	START-STOP INTERFACE	
[T]	TEMPERATURE INDICATION	
[V]	VENTILATION/RECIRCULATION CONTROL	
[PS]	POSITION	
[O <sub>2</sub> ]	FLUE GAS ANALYSIS, OXYGEN	
[Ca]	FLUE GAS ANALYSIS, CARBON MONOXIDE	

[FD]	FURNACE DRAFT DIFFERENTIAL PRESSURE
[DS]	HIGH-LOW DEMAND SIGNAL SELECTOR
[TC]	TEMPERATURE CONTROLLER
[PC]	PRESSURE CONTROLLER
[STR]	MOTOR STARTER
	SENSOR INSTALLED IN THERMOMETER WELL
	SENSOR INSTALLED IN DUCT OR PLENUM
CHW	CHILLED WATER
EA	EXHAUST AIR
SA	SUPPLY AIR
RA	RETURN AIR
OA	OUTSIDE AIR
MA	MIXED AIR
WB	WET BULB
DB	DRY BULB
OAD	OUTSIDE AIR DAMPER
RAD	RETURN AIR DAMPER
EAD	EXHAUST AIR DAMPER
MZD	MULTIZONE DAMPER
RH	RELATIVE HUMIDITY

Symbols and Abbreviations



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B2812E12

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER OPTIMIZATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	25713.
B. SIOH	\$	1415.
C. DESIGN COST	\$	1543.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	25804.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	25804.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	307.	\$ 896.	12.48	11188.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		307.	\$ 896.		\$ 11188.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -14057.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -14057.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 3692.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F= \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -647.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -2869.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.11  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)      SPB=1F/4      -39.91

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:**  
**SYSTEM MODIFICATION:** RENOVATE BOILERS  
**SYSTEMS TO MODIFY:** BOILERS 1, 2, AND 3

ECO - 9

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-9, renovate or replace existing boilers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	27,451	27,451
ECO	--	--	26,830	26,830
Savings (Baseline-ECO)	0	0	621	621

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu =	\$0 per year
Nat. Gas:	621 MMBtu/Yr	X	\$2.92 /MMBtu =	\$1,813 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$1,813 =</b>	<b>\$1,813 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$1,056 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$1,056</b>	<b>=</b>	<b>(\$1,056) per year</b>

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 BASELINE-1

\*\* TOTAL \*\*

SYSTEM C1 HEATING, COOLING, DOMESTIC HW, AND DIST. LOSS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	27450.
PEAK DAY GAS CONSUMP., 1000 CU FT	237.
ELECTRICAL CONSUMPTION, KWH	479788.
PEAK KW DEMAND (15 MIN BASIS)	192.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	479788.
ON-PEAK KW DEMAND (15 MIN BASIS)	192.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3027
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 BOILER ECO-3

\*\* TOTAL \*\*

SYSTEM C1 HEATING, COOLING, DOMESTIC HW, AND DIST. LOSS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	26830.
PEAK DAY GAS CONSUMP., 1000 CU FT	237.
ELECTRICAL CONSUMPTION, KWH	479788.
PEAK KW DEMAND (15 MIN BASIS)	192.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	479788.
ON-PEAK KW DEMAND (15 MIN BASIS)	192.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3027
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B2812EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER RENOVATION

ANALYSIS DATE: 04-09-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT
 

A. CONSTRUCTION COST	\$	6012.
B. SIOH	\$	331.
C. DESIGN COST	\$	361.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	6034.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	6034.
  
2. ENERGY SAVINGS (+) / COST (-)  
 ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS
 

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	621.	\$ 1813.	12.48	22630.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		621.	\$ 1813.		\$ 22630.
  
3. NON ENERGY SAVINGS(+) / COST(-)
 

A. ANNUAL RECURRING (+/-)	\$	-1056.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-9620.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-9620.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	7468.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= _____		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		
  
4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 757.
5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 13010.
6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 2.16  
 (IF < 1 PROJECT DOES NOT QUALIFY)
7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 7.97

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 16  
**SYSTEM MODIFICATION:** ENGINE DRIVEN CHILLER  
**SYSTEMS TO MODIFY:** CHILLER 1

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-16, install nat. gas engine driven chiller.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	192	426,000	5,252	6,706
ECO	48	148,000	6,702	7,207
Savings (Baseline-ECO)	144	278,000	(1,450)	(501)

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	949 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$3,809 per year
Nat. Gas:	-1450 MMBtu/Yr	X	\$2.92 /MMBtu	=	(\$4,234)per year
<b>Total Energy Cost Savings:</b>		<b>\$3,809 +</b>	<b>(\$4,234)</b>	<b>=</b>	<b>(\$425) per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	144 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$3,088 per year		
Maintenance:	= (-)		\$384 per year		
<b>Total:</b>	<b>\$3,088</b>	<b>-</b>	<b>\$384</b>	<b>=</b>	<b>\$2,704 per year</b>

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

## CENTRAL PLANT 2812 BASELINE-1

		***** PURCHASED ELECTRICAL *****									
		GAS	GAS	ON-PK	ON-PK	MID-PK	MID-PK	OFF-PK	OFF-PK	AUX	AUX
		DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	FUEL	FUEL
		MCF	MCF	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	CONSUMP	HRS
C1	1	237.	7351.	15.	11.	0.	0.	0.	0.	0.	0.
C1	2	237.	6124.	15.	10.	0.	0.	0.	0.	0.	0.
C1	3	165.	4512.	15.	11.	0.	0.	0.	0.	0.	0.
C1	4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	5	0.	0.	108.	65.	0.	0.	0.	0.	0.	0.
C1	6	0.	0.	171.	87.	0.	0.	0.	0.	0.	0.
C1	7	0.	0.	189.	97.	0.	0.	0.	0.	0.	0.
C1	8	0.	0.	192.	98.	0.	0.	0.	0.	0.	0.
C1	9	0.	0.	148.	79.	0.	0.	0.	0.	0.	0.
C1	10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	11	131.	3330.	15.	11.	0.	0.	0.	0.	0.	0.
C1	12	223.	6134.	15.	11.	0.	0.	0.	0.	0.	0.

Electrical Consumption May through September, 426,000 kWh  
 Electrical Demand Peak, August, 192 kW

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 ECO-15

		GAS		ON-PK		ON-PK		MID-PK		MID-PK		OFF-PK		OFF-PK		AUX		AUX	
		DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	FUEL	FUEL	FUEL	FUEL
		MCF	MCF	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	CONSUMP	HRS	CONSUMP	HRS
C1	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	4	43.	1053.	8.	5.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	5	49.	1444.	43.	30.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	6	47.	1295.	47.	29.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	7	46.	1304.	48.	30.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	8	46.	1303.	48.	30.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	9	49.	1356.	45.	29.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	10	43.	1089.	8.	6.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Gas Consumption May through September, 6702 MMBtu

Electrical Consumption May through September, 148,000 kWh

Electrical Demand Peak, August, 48 kW

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 BASELINE-2

		***** PURCHASED ELECTRICAL *****									
		GAS	GAS	ON-PK	ON-PK	MID-PK	MID-PK	OFF-PK	OFF-PK	AUX	AUX
		DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	FUEL	FUEL
		MCF	MCF	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	CONSUMP	HRS
C1	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	4	39.	1030.	8.	5.	0.	0.	0.	0.	0.	0.
C1	5	39.	1064.	8.	6.	0.	0.	0.	0.	0.	0.
C1	6	40.	1030.	8.	5.	0.	0.	0.	0.	0.	0.
C1	7	39.	1064.	8.	6.	0.	0.	0.	0.	0.	0.
C1	8	39.	1064.	8.	6.	0.	0.	0.	0.	0.	0.
C1	9	39.	1030.	8.	5.	0.	0.	0.	0.	0.	0.
C1	10	39.	1064.	8.	6.	0.	0.	0.	0.	0.	0.
C1	11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Gas Consumption May through September, 5252 MMBtu

# TECOCHILL<sup>TM</sup>

## Gas Engine Driven Chiller Systems



## Centrifugal Compressor Line

- 30 to 95% Energy Savings
- Fully Automatic Unattended Operation
- Continuous 20 to 100% Modulation
- Open Drive Compressor
- Hot Water Available
- Remote Diagnostics
- Made in U.S.A.

TECOCHILL centrifugal chillers provide cost effective and reliable chilled water for commercial, industrial and institutional cooling needs. The chillers combine the familiarity of vapor compression refrigeration with the energy efficiency of TecoDrive, a natural gas prime mover. TECOCHILL chillers provide substantial savings over electric and absorption chillers by reducing energy costs 30 to 95%. These savings are due to an exceptionally efficient design, lower utility costs and avoided electric demand charges.

The TECOCHILL CH-500 chiller uses two TecoDrive engines directly coupled to open-drive centrifugal compressors. The TECOCHILL CH-250 chiller uses a single TecoDrive engine. TecoDrive engines have earned a strong reputation for reliability and performance in the HVAC community. This reputation has resulted from millions of hours of operation in chillers and cogeneration modules.

TECOCHILL chillers provide the highest coefficient of performance (COP) of any type of gas chiller. The inherent variable speed capability of the TecoDrive engine and compressor team offers even higher part-load system efficiencies and superior load following capability. Continuous modulation from 20 to 100% provides customers with precisely controlled chilled water temperature.

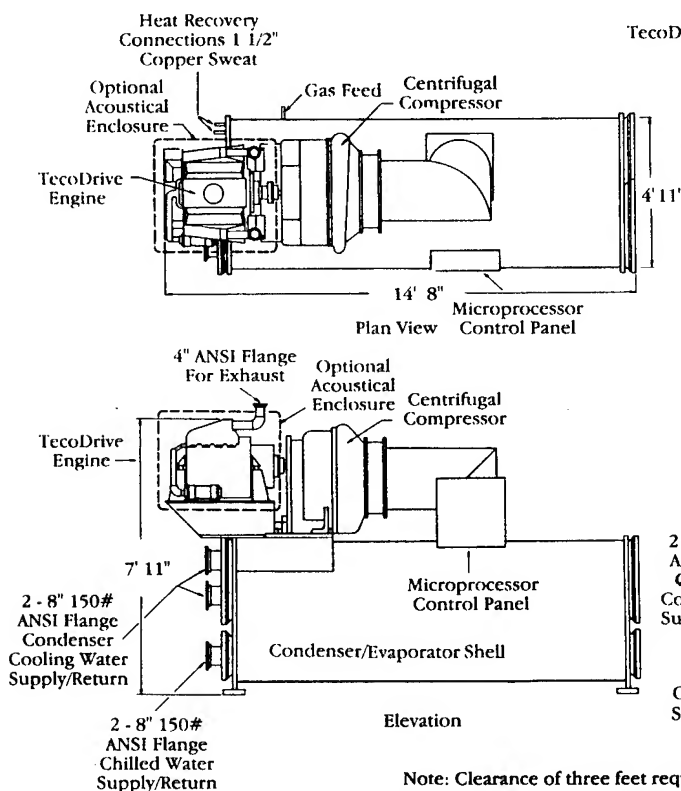
A powerful microprocessor based control system provides fully automatic operation, continuous chiller monitoring, digital display, fault and safety diagnostics and convenient interface to energy management systems in a user-friendly package. These features have resulted in a significant reduction in service costs.

Optional equipment includes a heat recovery package that yields as much as 1,700,000 Btu/hr of hot water which can supplement boilers or other thermal needs. Acoustical enclosures are available that reduce noise level. A remote monitoring and control system is available that permits remote operation and diagnostics via telephone and personal computer.

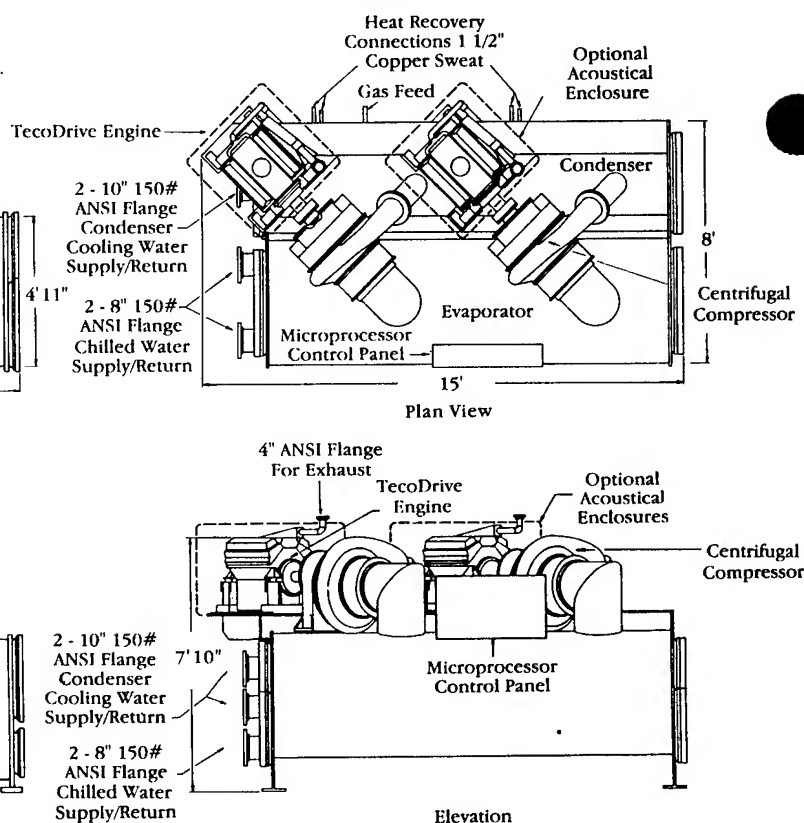
Made in the USA, TECOCHILL chillers are readily available and serviced by factory-trained local HVAC service professionals. TECOCHILL chillers are equal in size to electric chillers and smaller than absorption chillers. Also, open-drive compressors allow easier conversion to alternate refrigerants in the future. The chiller has been designed for ease of installation and with standard connections.

A cooling system evaluation is no longer complete without a TECOCHILL comparison. For further information, please contact Tecogen Inc. directly or our local sales representative.

**TECOCHILL CH-250**



**TECOCHILL CH-500**



Note: Clearance of three feet required on all sides. Scale: 3/16" = 1 ft.  
All specifications and materials subject to change without notice.  
All specifications and ratings are +5%

# GENERAL SPECIFICATIONS

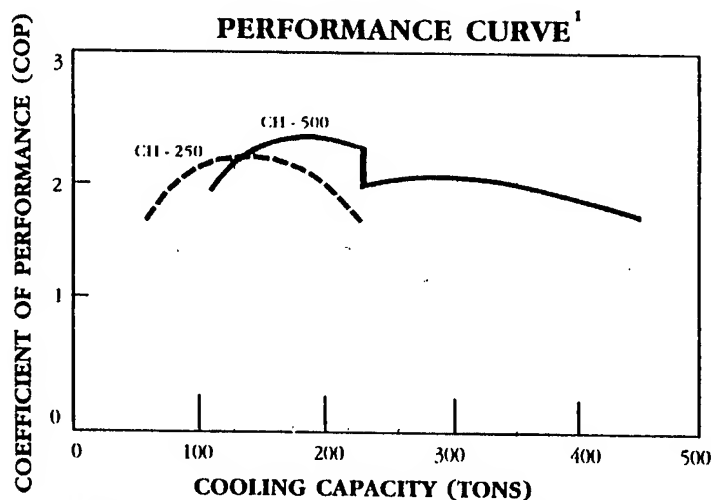
Model	CH - 250	CH - 500
Capacity (Tons) <sup>1</sup>	<del>230</del> 220	<del>460</del> 430
COP		
Full load	1.7	1.7
Integrated Part Load Value (IPLV)	2.0	2.0
RPM Full Load	3000	3000
Gas Input (SCFH) <sup>2</sup> @ 6 - 28 in. H <sub>2</sub> O	1750	3500
Recoverable Heat at Full Load (BTU/H) <sup>3</sup>	850,000	1,700,000
Acoustic Level (dBA) @ 20 ft. with Optional Enclosure	82	85
Electric Power Requirements	208 VAC Three phase, 35 Amps Service, 4 kW	208 VAC Three phase, 50 Amps Service, 7 kW
Chilled Water Flow (GPM)	600	1200
Cooling Tower Requirements		
Condenser Flow Rate (GPM)	750	1500
Pressure Drop (ft. H <sub>2</sub> O)	11	11
Temperatures, without Exhaust Heat Exchangers (°F) <sup>3</sup>	85.0 - 95.0	85.0 - 95.0
Temperatures, with Exhaust Heat Exchangers (°F) <sup>3</sup>	85.0 - 96.3	85.0 - 96.3
Exhaust		
Without Exhaust Heat Exchangers <sup>3</sup>	4 in. ANSI Flange, 300 SCFM, 26 in. of water max. back pressure, 1200°F max. temperature	(Same per engine)
With Exhaust Heat Exchangers <sup>3</sup>	4 in. ANSI Flange, 300 SCFM, 16 in. of water max. back pressure, 300°F max. temperature	(Same per engine)
Refrigerant	R-11 (1,010 lbs.)	R-11 (1,770 lbs)
TecoDrive™ Engines	One	Two
Rigging Weight (lbs.)	18,000	26,000
Dimensions	14'8" long x 4'11" wide x 7'11" high	15' long x 8' wide x 7'10" high

Note 1. Per ARI 550 - 88 Method

Note 2. HHV 1020 BTU/SCF

Note 3. 60% of heat from engine jacket, exhaust manifold

and oil cooler; 40% from engine exhaust heat exchanger



All specifications and materials subject to change without notice.  
All specifications and ratings are +5%



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 2812EC15

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: NAT. GAS ENGINE DRIVEN CHILLER  
REPLACEMENT

ANALYSIS DATE: 04-15-91 ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	421406.
B. SIOH	\$	23178.
C. DESIGN COST	\$	25285.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	422882.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	422882.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	949.	\$ 3809.	11.37	43313.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	-1450.	\$ -4234.	17.52	-74180.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		-501.	\$ -425.		\$ -30867.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	2704.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	31502.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	31502.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ -10186.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = - .10

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 2279.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 635.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .00

(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 185.52

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 2812  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 17  
**SYSTEM MODIFICATION:** DECENTALIZE BOILERS, ELEC. WATER HEATER IN EACH BLDG  
**SYSTEMS TO MODIFY:** NEW ELEC. WATER HEATER

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-17, install electric boilers for summer DHW.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	8	38,000	7,346	7,476
ECO	184	765,000	0	2,611
Savings (Baseline-ECO)	(176)	(727,000)	7,346	4,865

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: -2481 MMBtu/Yr X \$4.0141 /MMBtu = (\$9,960) per year  
 Nat. Gas: 7346 MMBtu/Yr X \$2.92 /MMBtu = \$21,450 per year  
**Total Energy Cost Savings: (\$9,960) + \$21,450 = \$11,490 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: -176 kW/month X \$1.787 /kW X 12 months/year  
 = (+) (\$3,774) per year  
 Maintenance: = (-) \$0 per year  
**Total: (\$3,774) - \$0 = (\$3,774) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 BASELINE-1

\*\* TOTAL \*\*

SYSTEM C1 HEATING, COOLING, DOMESTIC HW, AND DIST. LOSS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	27450.
PEAK DAY GAS CONSUMP., 1000 CU FT	237.
ELECTRICAL CONSUMPTION, KWH	479788.
PEAK KW DEMAND (15 MIN BASIS)	192.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	479788.
ON-PEAK KW DEMAND (15 MIN BASIS)	192.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3027
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 2812 BASELINE-2

\*\* TOTAL \*\*

## SYSTEM C1 SUMMER HW AND DISTRIBUTION LOSS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7348.
PEAK DAY GAS CONSUMP., 1000 CU FT	40.
ELECTRICAL CONSUMPTION, KWH	38520.
PEAK KW DEMAND (60 MIN BASIS)	8.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	38520.
ON-PEAK KW DEMAND (60 MIN BASIS)	8.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (60 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (60 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
BOILER OPERATING HOURS	
BOILER 1	5136
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

CENTRAL PLANT 2812 BOILER ECO-3B

\*\* TOTAL \*\*

SYSTEM E1 ELECTRIC HW BOILER FOR EACH BLDG.

FUEL AND POWER CONSUMPTION	SYSTEM E1
TOTAL GAS CONSUMP., 1000 CU FT	0.
PEAK DAY GAS CONSUMP., 1000 CU FT	0.
ELECTRICAL CONSUMPTION, KWH	764709.
PEAK KW DEMAND (15 MIN BASIS)	184.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	764709.
ON-PEAK KW DEMAND (15 MIN BASIS)	184.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B2812E3B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ELECTRIC BOILER

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$ 171638.
B. SIOH	\$ 9440.
C. DESIGN COST	\$ 10299.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$ 172239.
E. SALVAGE VALUE COST	-\$ 0.
F. TOTAL INVESTMENT (1D-1E)	\$ 172239.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	-2478.	\$ -9947.	11.37	-113094.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	7346.	\$ 21450.	17.52	375810.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		4868.	\$ 11504.		\$ 262716.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      11.65

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -43967.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -43967.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 86696.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 7730.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 218749.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.27  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 22.28

CENTRAL PLANT 3442

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 3442  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 1  
**SYSTEM MODIFICATION:** ADD INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:** CHILLER 1 AND 2 COMBINED

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-1, install instrumentation to facilitate efficient operation of chiller plant. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	1,340,000	0	4,573
ECO	--	1,131,000	0	3,860
Savings (Baseline-ECO)	0	209,000	0	713

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 713 MMBtu/Yr X \$4.0141 /MMBtu = \$2,863 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$2,863 + \$0 = \$2,863 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$228 per year  
**Total: \$0 - \$228 = (\$228) per year**

PC-CUBE VERSION 2.0.3

Central Plant 3442 Baseline

\*\* TOTAL \*\*

## SYSTEM C1 PLANT 3442 BASELINE

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	0.
PEAK DAY GAS CONSUMP., 1000 CU FT	0.
ELECTRICAL CONSUMPTION, KWH	1340162.
PEAK KW DEMAND (15 MIN BASIS)	590.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	1340162.
ON-PEAK KW DEMAND (15 MIN BASIS)	590.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	3672
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

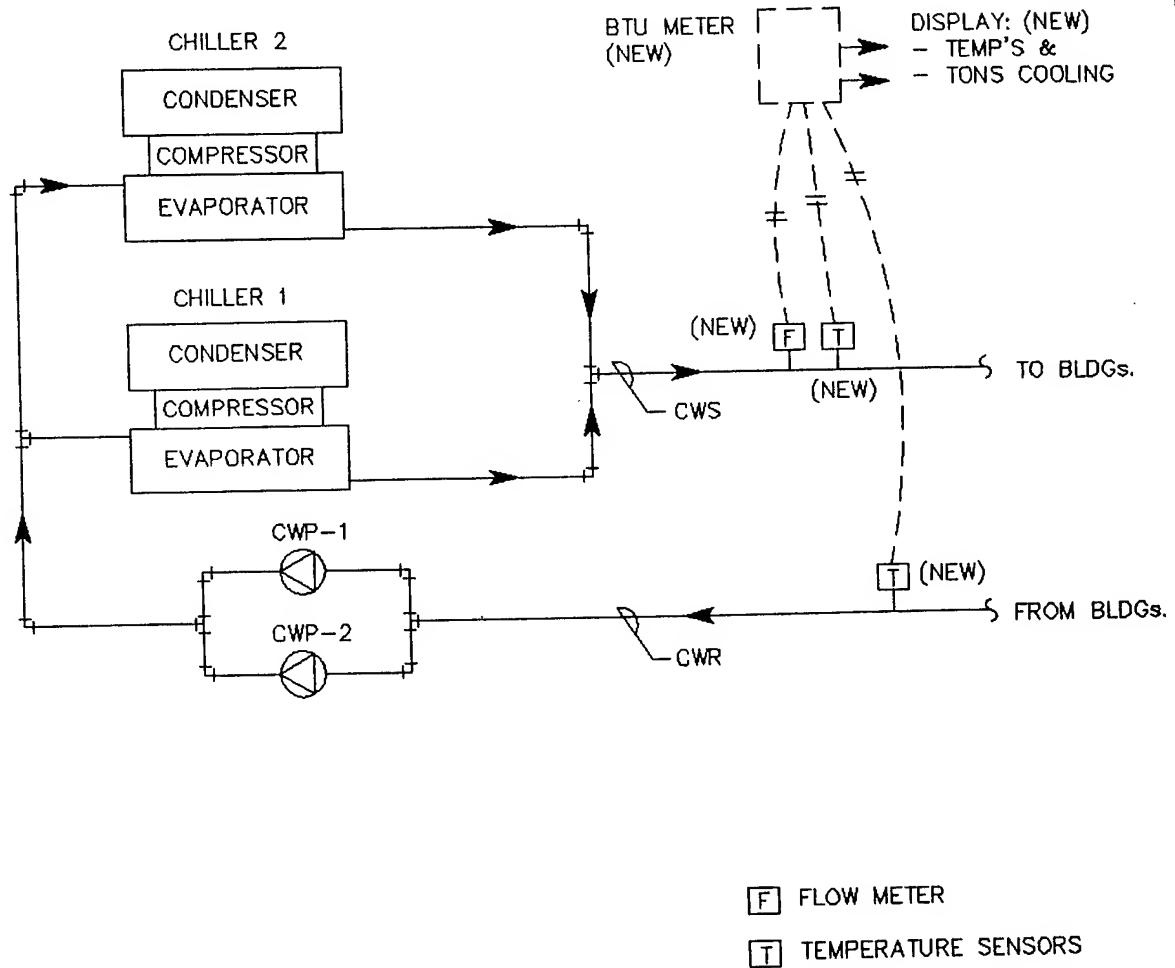
CENTRAL PLANT 3442 CHILLER ECO-1

\*\* TOTAL \*\*

## SYSTEM C1 PLANT 3442 BASELINE

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	0.
PEAK DAY GAS CONSUMP., 1000 CU FT	0.
ELECTRICAL CONSUMPTION, KWH	1130025.
PEAK KW DEMAND (15 MIN BASIS)	614.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	1130025.
ON-PEAK KW DEMAND (15 MIN BASIS)	614.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	736
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# ECO-1, INSTRUMENTATION FOR CHILLER PLANT (TYPICAL)



[C-ECO-1.DWG]



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C3442ECO

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER INSTRUMENTATION

ANALYSIS DATE: 04-12-91 ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	3803.
B. SIOH	\$	210.
C. DESIGN COST	\$	229.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	3818.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	3818.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	713.	\$ 2862.	8.78	25128.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		713.	\$ 2862.		\$ 25128.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)	9.11	\$ -228.
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$ -2077.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -2077.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33) \$ 8292.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ 2634.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 23051.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 6.04  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)  $SPB=1F/4$  1.45

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 3442  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-2  
**SYSTEM MODIFICATION:** CHILLER OPTIMIZATION, ADD INSTRUMENTATION  
**SYSTEMS TO MODIFY:** CHILLER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-2, install instrumentation connected to EMCS for chiller optimization. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	1,340,000	0	4,573
ECO	--	1,059,000	0	3,614
Savings (Baseline-ECO)	0	281,000	0	959

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 959 MMBtu/Yr X \$4.0141 /MMBtu = \$3,850 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$3,850 + \$0 = \$3,850 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$936 per year  
**Total: \$0 - \$936 = (\$936) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

Central Plant 3442 Baseline

\*\* TOTAL \*\*

SYSTEM C1 PLANT 3442 BASELINE	
FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	0.
PEAK DAY GAS CONSUMP., 1000 CU FT	0.
ELECTRICAL CONSUMPTION, KWH	1340162.
PEAK KW DEMAND (15 MIN BASIS)	590.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	1340162.
ON-PEAK KW DEMAND (15 MIN BASIS)	590.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	3672
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

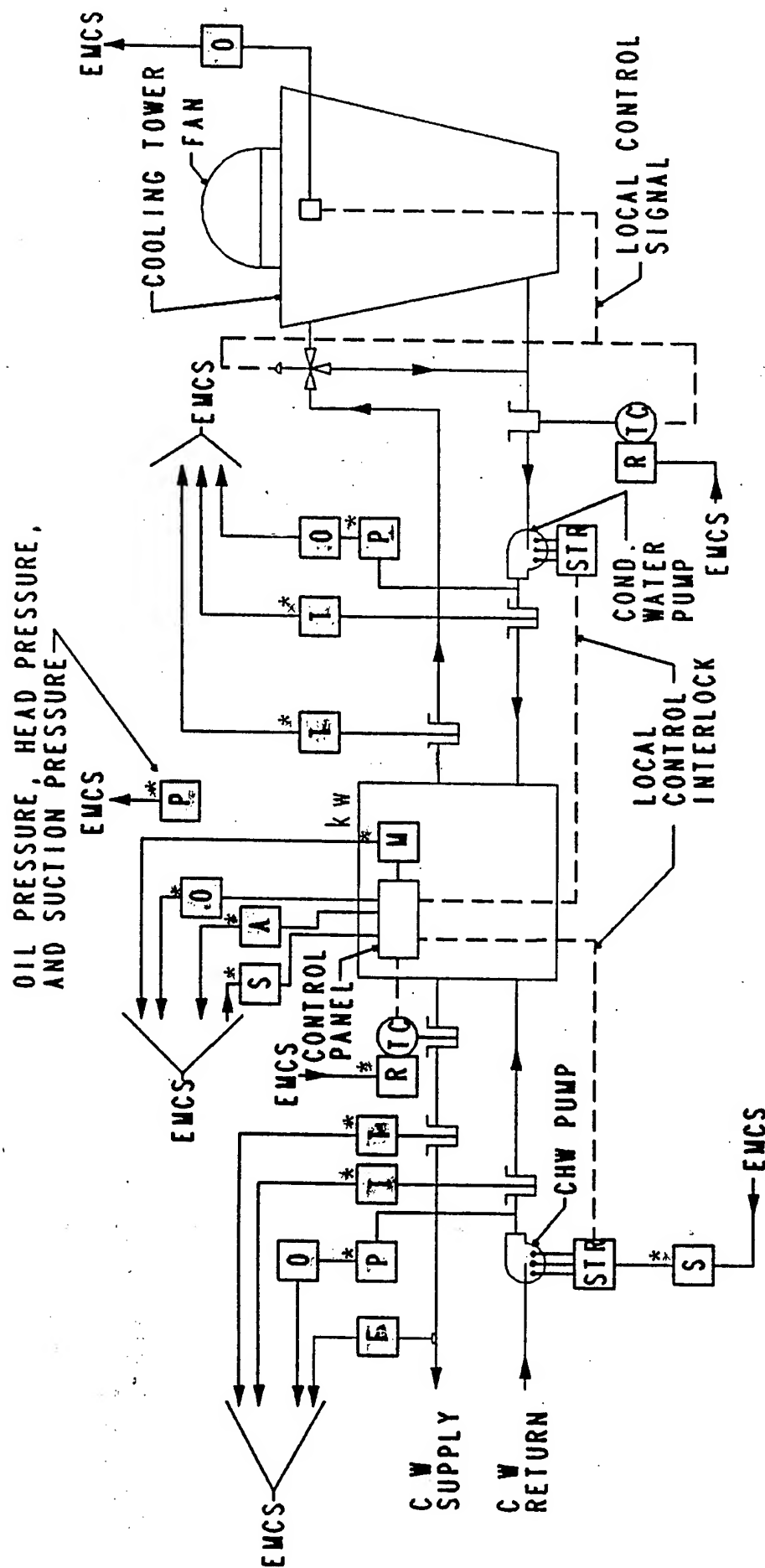
PC-CUBE VERSION 2.0.3

CENTRAL PLANT 3442 CHILLER ECO-2

\*\* TOTAL \*\*

SYSTEM C1 PLANT 3442 BASELINE


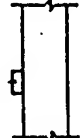
FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	0.
PEAK DAY GAS CONSUMP., 1000 CU FT	0.
ELECTRICAL CONSUMPTION, KWH	1058963.
PEAK KW DEMAND (15 MIN BASIS)	595.
PURCHASED ELECTRIC POWER	1058963.
ON-PEAK CONSUMPTION KWH	595.
ON-PEAK KW DEMAND (15 MIN BASIS)	0.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	3672
CHILLER 1	664
CHILLER 2	
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



Water cooled chiller

\* - Points included on proposed EMCS design, existing.  
All other points are new.

→	EMCS	SIGNAL TRANSMITTED TO EMCS
←	EMCS	SIGNAL TRANSMITTED FROM EMCS
[A]	ALARM CONTACT SIGNAL	
[E]	ECONOMIZER CONTROL INTERFACE	
[F]	FLOW INDICATION	
[FL]	FLAME INDICATION	
[H]	HUMIDITY INDICATION	
[P]	PRESSURE INDICATION	
[LV]	LEVEL INDICATION	
[M]	METER	
[O]	ON-OFF STATUS SIGNAL	
[DP]	DIFFERENTIAL PRESSURE SWITCH	
[R]	CONTROLLER RESET INTERFACE	
[S]	START-STOP INTERFACE	
[T]	TEMPERATURE INDICATION	
[V]	VENTILATION/RECIRCULATION CONTROL	
[PS]	POSITION	
[O <sub>2</sub> ]	FLUE GAS ANALYSIS, OXYGEN	
[CO]	FLUE GAS ANALYSIS, CARBON MONOXIDE	

[FD]	FURNACE DRAFT DIFFERENTIAL PRESSURE
[DS]	HIGH-LOW DEMAND SIGNAL SELECTOR
[TC]	TEMPERATURE CONTROLLER
[PC]	PRESSURE CONTROLLER
[STR]	MOTOR STARTER
	SENSOR INSTALLED IN THERMOMETER WELL
	SENSOR INSTALLED IN DUCT OR PLENUM
CHW	CHILLED WATER
EA	EXHAUST AIR
SA	SUPPLY AIR
RA	RETURN AIR
OA	OUTSIDE AIR
MA	MIXED AIR
WB	WET BULB
DB	DRY BULB
OAD	OUTSIDE AIR DAMPER
RAD	RETURN AIR DAMPER
EAD	EXHAUST AIR DAMPER
MZD	MULTIZONE DAMPER
RH	RELATIVE HUMIDITY

Symbols and Abbreviations



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C3442ECO

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER OPTIMIZATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	15592.
B. SIOH	\$	858.
C. DESIGN COST	\$	936.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	15647.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	15647.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	959.	\$ 3849.	8.78	33798.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		959.	\$ 3849.		\$ 33798.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -8527.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -8527.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 11153.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 2913.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 25271.

6. DISCOUNTED SAVINGS RATIO      (SIR)=(5 / 1F)= 1.62

(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)      SPB=1F/4      5.37

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 3442  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	780	0	0	0

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	780 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$16,726 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$16,726</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$16,726 per year</b>

[ECO-SHT.WK3]

# A new application of an old idea that can cut air conditioning energy costs in half.

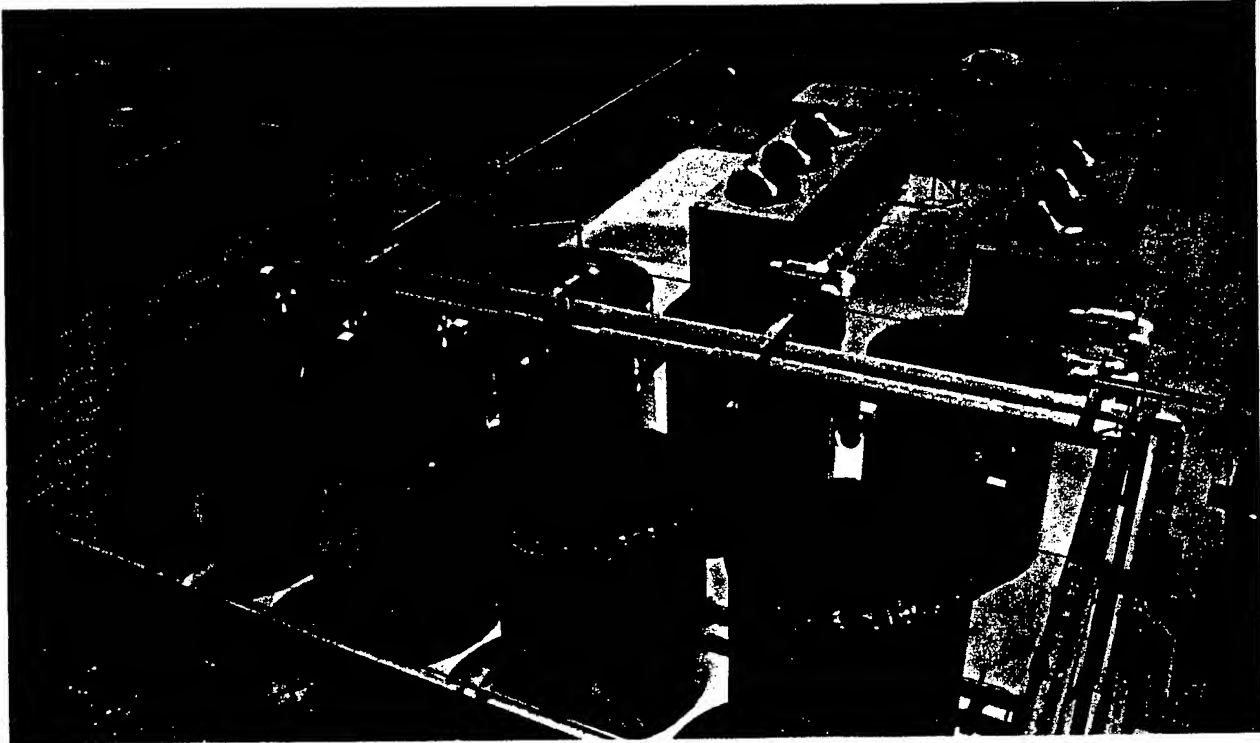
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

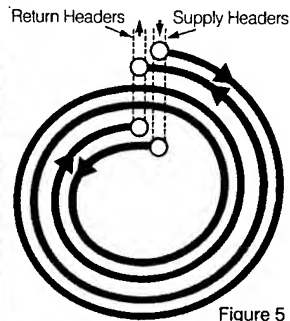
Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes—90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.



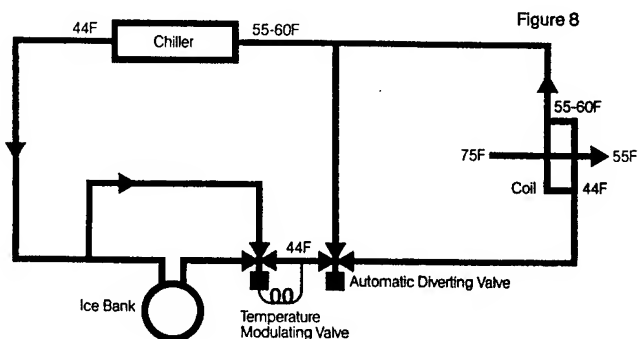
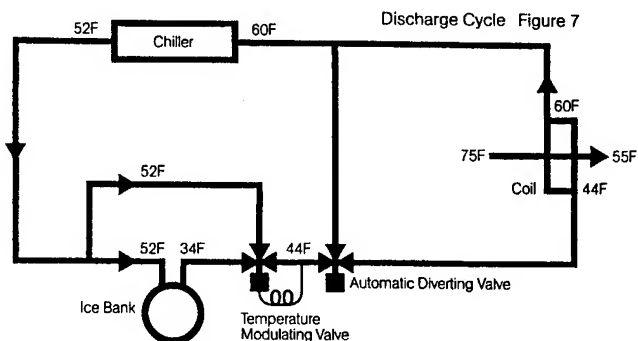
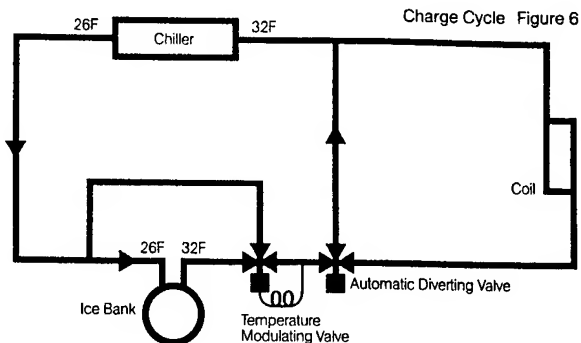
Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.



The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's Dowtherm® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 3442EC4

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM

ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$ 288000.
B. SIOH	\$ 15840.
C. DESIGN COST	\$ 17280.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$ 289008.
E. SALVAGE VALUE COST	-\$ 0.
F. TOTAL INVESTMENT (1D-1E)	\$ 289008.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$ 16726.
(1) DISCOUNT FACTOR (TABLE A)	11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$ 194858.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$ 194858.
D. PROJECT NON ENERGY QUALIFICATION TEST	
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$ 0.
A IF 3D1 IS = OR > 3C GO TO ITEM 4	
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=	.00
C IF 3D1B IS = > 1 GO TO ITEM 4	
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY	

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ 16726.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 194858.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .67  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED)  $SPB=1F/4$  17.28

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 3442  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	46,756	--	160
ECO	--	10,872	--	37
Savings (Baseline-ECO)	0	35,884	0	122

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 122 MMBtu/Yr X \$4.0141 /MMBtu = \$492 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$492 + \$0 = \$492 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$597 per year  
 Total: \$0 - \$597 = (\$597) per year

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input. The calculations take into account multi-cell towers (part 7). The control sequence is:

- 0-25% load, fan 1, half speed cycling.
- 25-50% load, fan 1 half speed running, fan 2 half speed cycling:
- 50-75% load, fan 1 full speed cycling, fan 2 half speed running.
- 75-100% load, fan 1 full speed running, fan 2 full speed cycling.

kWh per bin, for % design loads less than 25% load = (fan 1 power kW) \* 14% \* (% design load / 25) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 25% to 50% load = (fan 1 power kW \* 14% \* 4 hours per bin \* days per month) \* ( fan 2 power kW \* 14% \* ((% design load - 25) / 25) \* 4 hours per bin \* days per month )

kWh per bin, for % design loads 50% to 75% load = (fan 2 power kW \* 14% \* 4 hours per bin \* days per month) \* ( fan 1 power kW \* ((% design load - 50) / 25) \* 4 hours per bin \* days per month )

kWh per bin, for % design loads 75% to 100% load = ( fan 1 power kW \* 4 hours per bin \* days per month ) + ( fan 2 power kW \* ((% design load - 75) / 25) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 3442	
DESIGN CONDITIONS	
- WBT (DB, DEG F)	77
- WATER FLOW (gpm)	3600
- CNWR (DEG F)	95
- CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
- AIR FLOW (LBS/MIN)	14940
HEAT REJECTION CAPACITY (Btu/min)	
	298800
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	40.57
TOTAL ENTHALPY	60.57
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	225594
MOTOR DATA	
- FAN 1 POWER (kW)	10
- FAN 2 POWER (kW)	10
- FAN 3 POWER (kW)	10
- FAN 4 POWER (kW)	10

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET-BULB AVERAGES (4 hour bins)						DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	77
MAY	57.1	56.6	61.2	63.9	63	59.4	77
JUNE	66.8	66.6	69.9	71	70.5	68.2	77
JULY	70.8	70.9	74.5	76	74.9	72.6	77
AUGUST	66.9	67	71	72	71	68.5	77
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	77
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	77

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	40.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	40.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	40.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	40.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	40.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	40.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	40.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK
	1-4	5-8	9-12	13-16	17-20	21-24	LOAD
							(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.7	0.7	0.3	0.3	10984000
JUNE	0.3	0.3	0.7	0.7	0.3	0.3	13259000
JULY	0.3	0.3	0.7	0.7	0.3	0.3	13259000
AUGUST	0.3	0.3	0.7	0.7	0.3	0.3	13259000
SEPTEMBER	0.3	0.3	0.7	0.7	0.3	0.3	13259000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.8	1.8	1.7	1.6	1.6	1.7	31
JUNE	1.5	1.5	1.3	1.3	1.3	1.4	30
JULY	1.3	1.3	1.1	1.1	1.1	1.2	31
AUGUST	1.5	1.4	1.3	1.2	1.3	1.4	31
SEPTEMBER	1.5	1.5	1.4	1.4	1.4	1.5	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

% DESIGN LOAD							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	13.8	13.7	34.8	37.0	15.5	14.4	31
JUNE	20.6	20.5	52.7	54.6	23.0	21.4	30
JULY	23.3	23.3	62.4	66.7	27.2	24.8	31
AUGUST	20.7	20.7	54.6	56.6	23.4	21.6	31
SEPTEMBER	19.7	19.6	49.4	50.9	20.9	20.0	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

SINGLE SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	704	698	1778	1889	793	735	
JUNE	1018	1013	2603	2699	1137	1059	
JULY	1187	1191	3186	3402	1389	1265	
AUGUST	1055	1058	2789	2888	1195	1104	
SEPTEMBER	974	969	2442	2516	1035	986	
OCTOBER	0	0	0	0	0	0	
TOTAL	4938	4928	12797	13394	5549	5150	46756

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	17	16	270	323	24	19	
JUNE	54	53	904	1007	75	61	
JULY	80	81	1551	1890	129	97	
AUGUST	56	57	1041	1156	82	65	
SEPTEMBER	47	47	746	816	57	49	
OCTOBER	0	0	0	0	0	0	
TOTAL	255	254	4512	5193	367	291	10872



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 3442EC5B  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER  
 ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	9951.
B. SIOH	\$	548.
C. DESIGN COST	\$	597.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	9986.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	9986.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	122.	\$ 492.	11.37	5589.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		122.	\$ 492.		\$ 5589.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-597.
(1) DISCOUNT FACTOR (TABLE A)		
(2) DISCOUNTED SAVING/COST (3A X 3A1)	11.65	\$ -6955.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-6955.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1845.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -105.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -1366.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.14  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -94.74

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 3442  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.  
 It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	4	12,880	0	44

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 44 MMBtu/Yr X \$4.0141 /MMBtu = \$176 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$176 + \$0 = \$176 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 4 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$86 per year  
 Maintenance: = (-) \$0 per year  
 Total: \$86 - \$0 = \$86 per year

[ECO-SHT.WK3]

# **HIGH EFFICIENCY MOTOR REPLACEMENT**

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR
730	CWP-1	150.0	179.0	147.0	0.87	460	90.19%	95.00%	5.73	2641	15120	\$330
	CWP-2	150.0	179.0	148.0	0.91	460	86.22%	95.00%	11.50	1873	21539	\$542
	CNWP-1	50.0	118.0	107.0	0.98	230	80.97%	93.00%	6.67	2641	17629	\$385
	CNWP-2	50.0	118.0	107.0	0.99	230	80.15%	93.00%	7.27	468	3405	\$203
	CNWP-3	NI	NI	NI								
	CTM-1	30.0	71.4	70.7	0.93	230	84.60%	92.40%	2.61	702	1834	\$81
	CTM-2	30.0	71.4	71.0	0.87	230	90.44%	92.40%	0.58	702	405	\$18
	HWP-1	50.0	125.0	117.5	0.87	230	86.10%	93.00%	3.51	3624	12722	\$250
	HWP-2	50.0	125.0	118.0	0.87	230	86.10%	93.00%	3.53	3624	12776	\$251
	DEMAND CREDIT		\$888		MMBtu		292	TOTAL	41		85430	\$2,058
914	CWP-1	40.0	48.0	41.3	0.87	460	89.69%	93.00%	1.14	3672	4178	\$82
	CNWP-1	15.0	19.0	14.4	0.82	460	90.15%	90.20%	0.01	3672	23	\$0
	CTM-1	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	CTM-2	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	HWP-1	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33
	HWP-2	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34
	DEMAND CREDIT		\$111		MMBtu		30	TOTAL	5		8932	\$233
	DEMAND CREDIT		\$111		MMBtu		30	TOTAL	5		8932	\$233
2812	CWP-1	20.0	27.0	23.0	0.77	460	90.07%	91.00%	0.16	3672	586	\$11
	CNWP-1	25.0	31.5	26.5	0.82	460	91.18%	91.70%	0.11	3672	394	\$8
	CTM-1	15.0	18.6	18.6	0.87	460	86.79%	90.20%	0.56	1167	655	\$21
	HWP-1	7.5	21.6	18.5	0.87	230	74.74%	88.50%	1.33	5163	6888	\$123
	HWP-2	7.5	21.6	19.0	0.87	230	74.74%	88.50%	1.37	3672	5031	\$98
	DEMAND CREDIT		\$76		MMBtu		46	TOTAL	4		13554	\$261
	DEMAND CREDIT		\$76		MMBtu		46	TOTAL	4		13554	\$261
3442	CWP-1	60.0	73.0	63.0	0.84	460	91.62%	94.50%	1.40	3672	5158	\$101
	CWP-2	60.0	73.0	63.4	0.84	460	91.62%	94.50%	1.41	3672	5191	\$101
	CNWP-1	40.0	52.0	41.0	0.78	460	92.34%	93.00%	0.20	3672	721	\$14
	CNWP-2	40.0	52.0	35.8	0.78	460	92.34%	93.00%	0.17	3672	629	\$12
	CTM-1	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-2	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-3	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-4	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	DEMAND CREDIT		\$90		MMBtu		44	TOTAL	4		12880	\$266
	DEMAND CREDIT		\$90		MMBtu		44	TOTAL	4		12880	\$266
4701	CWP-1	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CWP-2	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CNWP-1	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CNWP-2	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CTM-1	20.0	24.6	18.2	0.87	460	87.50%	91.00%	0.55	650	361	\$17
	CTM-2	15.0	19.2	16.5	0.87	440	87.90%	90.20%	0.32	650	206	\$10
	DEMAND CREDIT		\$65		MMBtu		16	TOTAL	3		4605	\$128
5676	HCP-1	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	HCP-2	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	10.5	9	0.79	460	84.66%	88.50%	0.29	1160	337	\$11
	DEMAND CREDIT		\$94		MMBtu		83	TOTAL	4		24287	\$427
5678	HCP-1	2.0	6.5	5.9	0.83	208	76.76%	84.00%	0.20	7296	1445	\$24
	HCP-2	2.0	6.5	5.7	0.83	208	76.76%	84.00%	0.19	7296	1396	\$23
	HCP-3	1.5	4.8	4.5	0.83	230	70.51%	84.00%	0.34	7296	2474	\$41
	HCP-4	2.0	6.3	5.8	0.83	230	71.62%	84.00%	0.39	7296	2878	\$48
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	11	9.6	0.75	460	85.12%	88.50%	0.26	1139	293	\$10
	DEMAND CREDIT		\$64		MMBtu		49	TOTAL	3		14412	\$262



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 3442EC6

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000      ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	23998.
B. SIOH	\$	1320.
C. DESIGN COST	\$	1440.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	24082.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	24082.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	44.	\$ 177.	11.37	2008.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		44.	\$ 177.		\$ 2008.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	85.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	990.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	990.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	663.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		.11
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 262.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 2998.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .12  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 92.05

**CENTRAL PLANT 4701**

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 1  
**SYSTEM MODIFICATION:** ADD INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:** CHILLER 1 AND 2 COMBINED

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-1, install instrumentation to facilitate efficient operation of chiller plant. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	306,000	7,876	8,920
ECO	--	235,000	7,876	8,678
Savings (Baseline-ECO)	0	71,000	0	242

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	242 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$973 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$973 +</b>	<b>\$0</b>	<b>=</b>	<b>\$973 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$0 per year
Maintenance:	=	(-)			\$320 per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$320</b>	<b>=</b>	<b>(\$320) per year</b>

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 4701 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

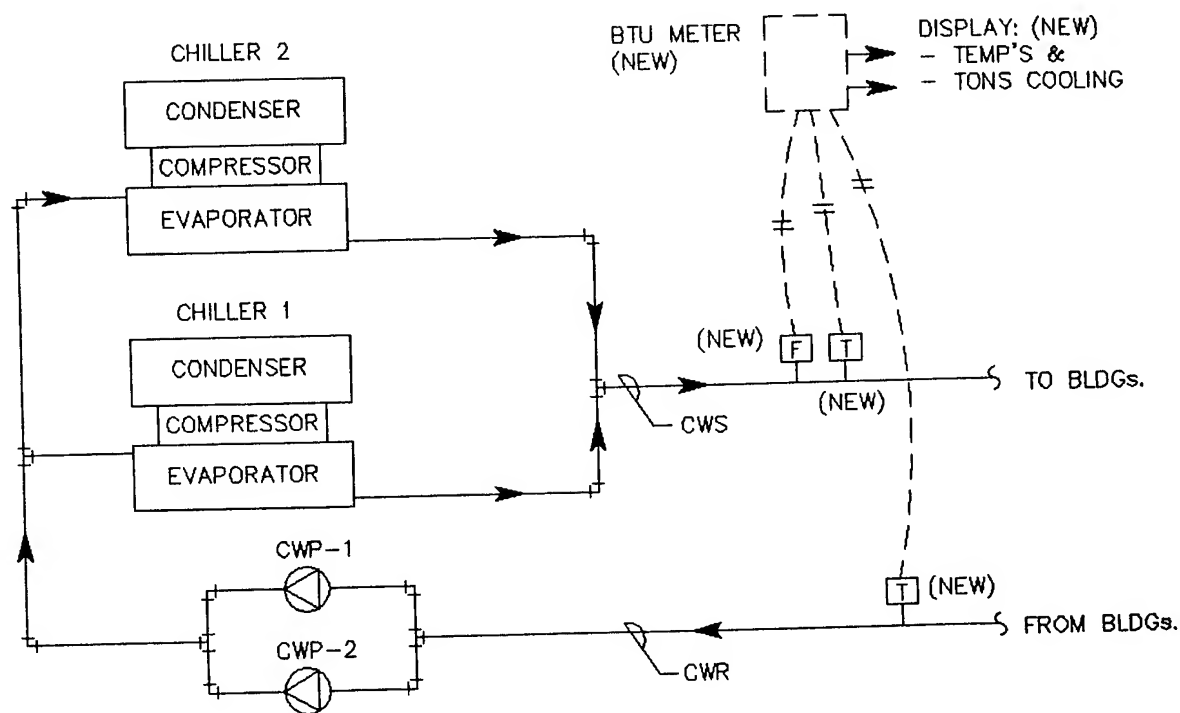
FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7875.
PEAK DAY GAS CONSUMP., 1000 CU FT	99.
ELECTRICAL CONSUMPTION, KWH	305028.
PEAK KW DEMAND (15 MIN BASIS)	396.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	305028.
ON-PEAK KW DEMAND (15 MIN BASIS)	396.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	1873
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

## SYSTEM C1 NORMAL HEATING AND COOLING

\*\* TOTAL \*\*

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7875.
PEAK DAY GAS CONSUMP., 1000 CU FT	99.
ELECTRICAL CONSUMPTION, KWH	234767.
PEAK KW DEMAND (15 MIN BASIS)	452.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	234767.
ON-PEAK KW DEMAND (15 MIN BASIS)	452.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	87
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# ECO-1, INSTRUMENTATION FOR CHILLER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[C-ECO-1.DWG]

## **COST ESTIMATE ANALYSIS**

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C4701ECO

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER INSTRUMENTATION

ANALYSIS DATE: 04-08-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	5327.
B. SIOH	\$	293.
C. DESIGN COST	\$	320.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5346.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5346.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	242.	\$ 971.	8.78	8529.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		242.	\$ 971.		\$ 8529.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	881.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	8026.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	8026.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	2814.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=	2.12	
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 1852.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 16555.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 3.10  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 2.89

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-2  
**SYSTEM MODIFICATION:** CHILLER OPTIMIZATION, ADD INSTRUMENTATION  
**SYSTEMS TO MODIFY:** CHILLER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-2, install instrumentation connected to EMCS for chiller optimization. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	306,000	0	1,044
ECO	--	128,000	0	437
Savings (Baseline-ECO)	0	178,000	0	608

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 608 MMBtu/Yr X \$4.0141 /MMBtu = \$2,439 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$2,439 + \$0 = \$2,439 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$234 per year  
 Total: \$0 - \$234 = (\$234) per year

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 4701 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

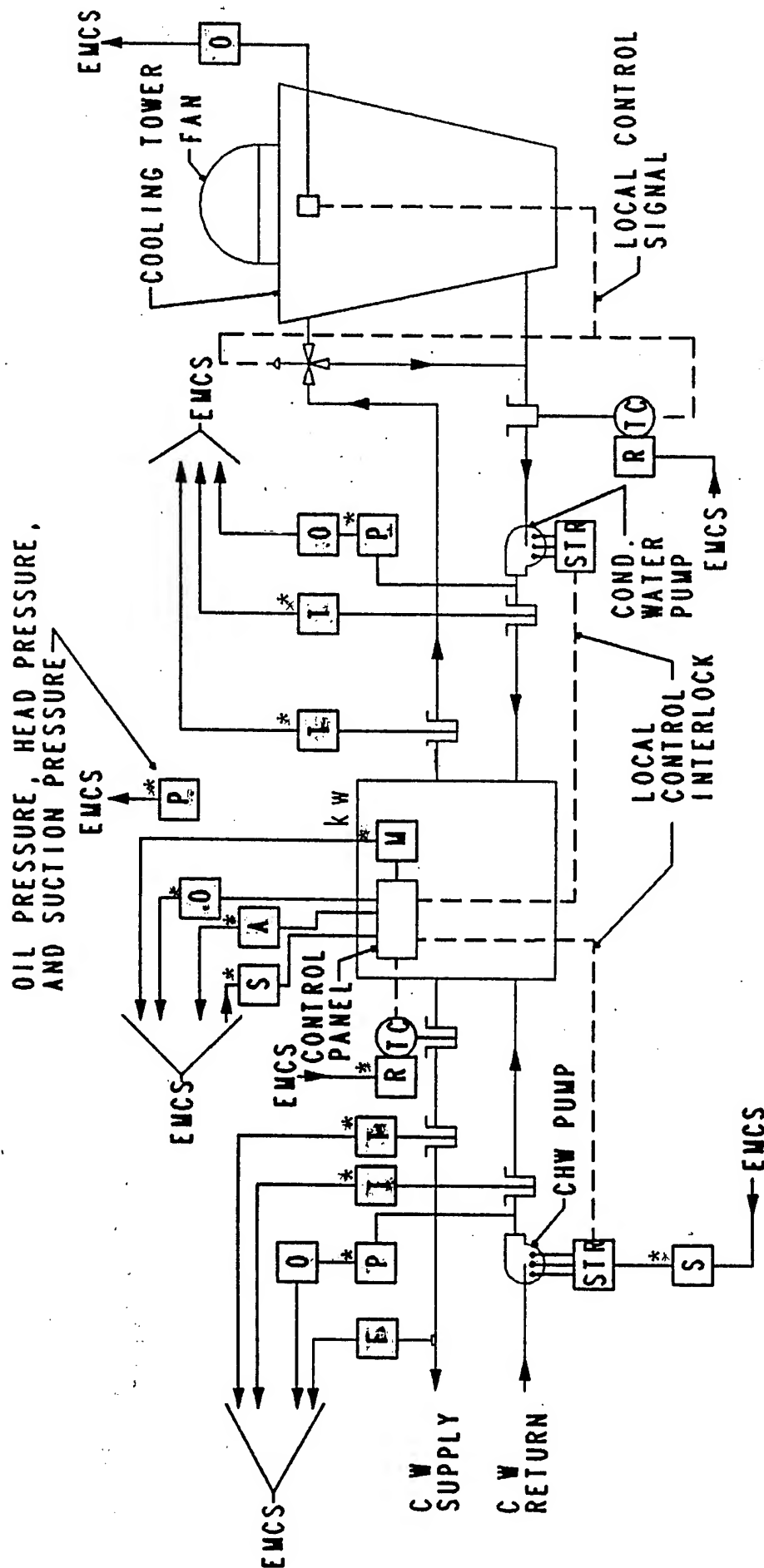
FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7875.
PEAK DAY GAS CONSUMP., 1000 CU FT	99.
ELECTRICAL CONSUMPTION, KWH	305028.
PEAK KW DEMAND (15 MIN BASIS)	396.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	305028.
ON-PEAK KW DEMAND (15 MIN BASIS)	396.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	1873
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

## CENTRAL PLANT 4701 CHILLER ECO-2

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

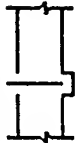
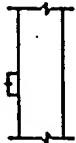
FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7875.
PEAK DAY GAS CONSUMP., 1000 CU FT	99.
ELECTRICAL CONSUMPTION, KWH	127570.
PEAK KW DEMAND (15 MIN BASIS)	430.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	127570.
ON-PEAK KW DEMAND (15 MIN BASIS)	430.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	87
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



Water cooled chiller

\* - Points included on proposed EMCS design, existing.  
All other points are new.

→	EMCS SIGNAL TRANSMITTED TO EMCS
←	EMCS SIGNAL TRANSMITTED FROM EMCS
[A]	ALARM CONTACT SIGNAL
[E]	ECONOMIZER CONTROL INTERFACE
[F]	FLOW INDICATION
[FL]	FLAME INDICATION
[H]	HUMIDITY INDICATION
[P]	PRESSURE INDICATION
[LV]	LEVEL INDICATION
[M]	METER
[O]	ON-OFF STATUS SIGNAL
[DP]	DIFFERENTIAL PRESSURE SWITCH
[R]	CONTROLLER RESET INTERFACE
[S]	START-STOP INTERFACE
[T]	TEMPERATURE INDICATION
[V]	VENTILATION/RECIRCULATION CONTROL
[PS]	POSITION
[O <sub>2</sub> ]	FLUE GAS ANALYSIS, OXYGEN
[Co]	FLUE GAS ANALYSIS, CARBON MONOXIDE

[FD]	FURNACE DRAFT DIFFERENTIAL PRESSURE
[DS]	HIGH-LOW DEMAND SIGNAL SELECTOR
[TC]	TEMPERATURE CONTROLLER
[PC]	PRESSURE CONTROLLER
[STR]	MOTOR STARTER
	SENSOR INSTALLED IN THERMOMETER WELL
	SENSOR INSTALLED IN DUCT OR PLENUM
CHW	CHILLED WATER
EA	EXHAUST AIR
SA	SUPPLY AIR
RA	RETURN AIR
OA	OUTSIDE AIR
MA	MIXED AIR
WB	WET BULB
DB	DRY BULB
OAD	OUTSIDE AIR DAMPER
RAD	RETURN AIR DAMPER
EAD	EXHAUST AIR DAMPER
MZD	MULTIZONE DAMPER
RH	RELATIVE HUMIDITY

Symbols and Abbreviations

## INVITATION NO./CONTRACT NO.

DACA 59-90-C-0087

CODE A	X	CODE B	CODE C
OTHER			

PROJECT	ENERGY SURVEY OF ARMY BOILER AND CHILLER
LOCATION	FT. SILL, OKLAHOMA

EFFECTIVE PRICING	DATE PREPARED
DATE APR. 91	04-Apr-91

# SHS OF

**DRAWING NO.**

CHECKED BY C

ESTIMATOR

TOTAL PAGES SHEET

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C4701ECO

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000      ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER OPTIMIZATION

ANALYSIS DATE: 04-08-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	16046.
B. SIOH	\$	883.
C. DESIGN COST	\$	963.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	16103.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	16103.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	608.	\$ 2441.	8.78	21428.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		608.	\$ 2441.		\$ 21428.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -2132.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -2132.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 7071.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 2207.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 19296.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.20  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 7.30

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-3  
**SYSTEM MODIFICATION:** CHILLER REPLACEMENT  
**SYSTEMS TO MODIFY:** CHILLER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-3, renovate or replace existing chillers. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	396	306,000	--	1,044
ECO	283	180,000	--	614
Savings (Baseline-ECO)	113	126,000	0	430

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	430 MMBtu/Yr	X	\$4.0141 /MMBtu =	\$1,726 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu =	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$1,726 +</b>	<b>\$0 =</b>	<b>\$1,726 per year</b>	

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	113 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$2,423 per year		
Maintenance:	= (-)		\$3,000 per year		
<b>Total:</b>	<b>\$2,423</b>	<b>-</b>	<b>\$3,000</b>	<b>=</b>	<b>(\$577) per year</b>

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 4701 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7875.
PEAK DAY GAS CONSUMP., 1000 CU FT	99.
ELECTRICAL CONSUMPTION, KWH	305028.
PEAK KW DEMAND (15 MIN BASIS)	396.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	305028.
ON-PEAK KW DEMAND (15 MIN BASIS)	396.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	1873
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C4701EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER REPLACEMENT

ANALYSIS DATE: 04-09-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	206932.
B. SIOH	\$	11382.
C. DESIGN COST	\$	12416.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	207657.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	207657.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	430.	\$ 1726.	11.37	19627.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		430.	\$ 1726.		\$ 19627.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-577.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-6722.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-6722.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	6477.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 1149.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 12905.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .06  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 180.69

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	583	0	0	0

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$0 + \$0 = \$0 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 583 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$12,502 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$12,502 - \$0 = \$12,502 per year**

[ECO-SHT.WK3]

# A new application of an old idea that can cut air conditioning energy costs in half.

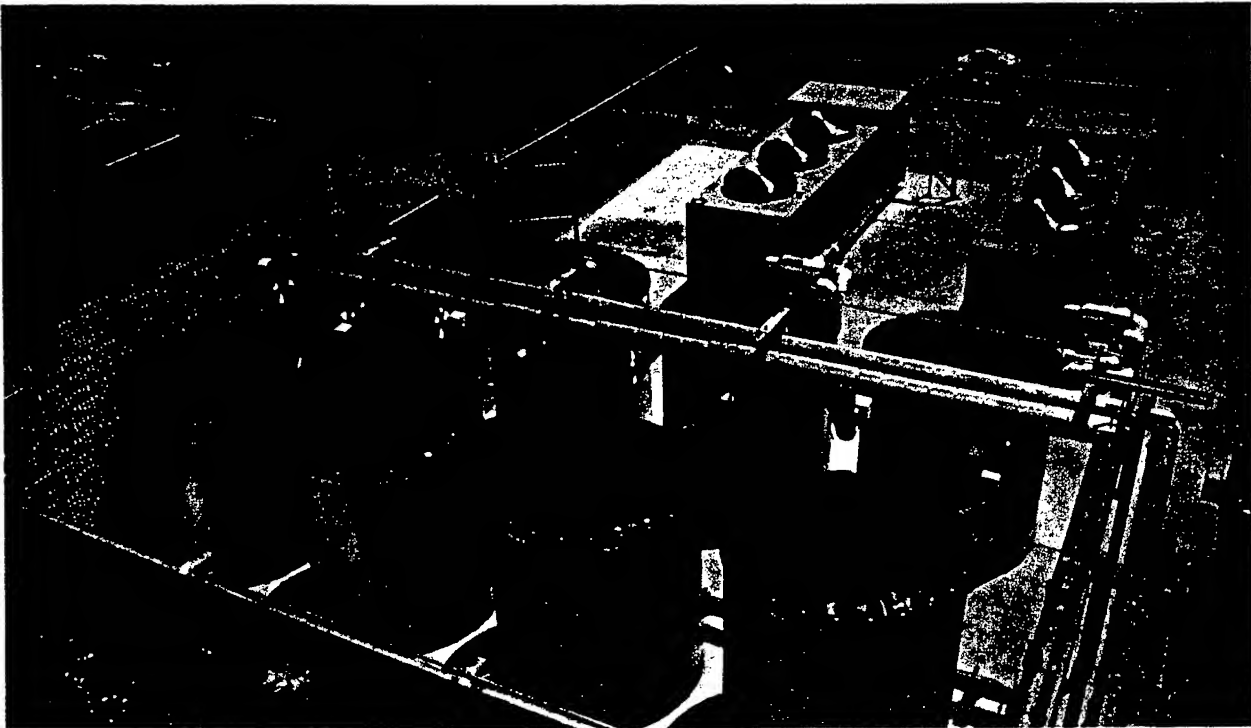
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes - 90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.

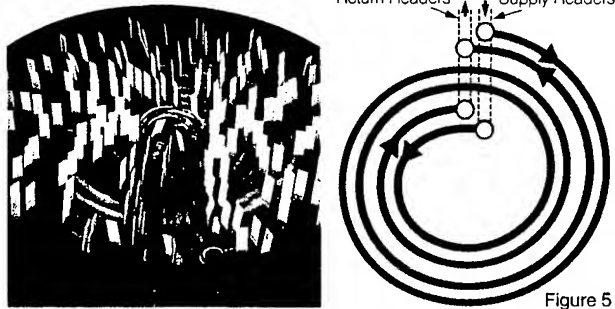


Figure 5

Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.

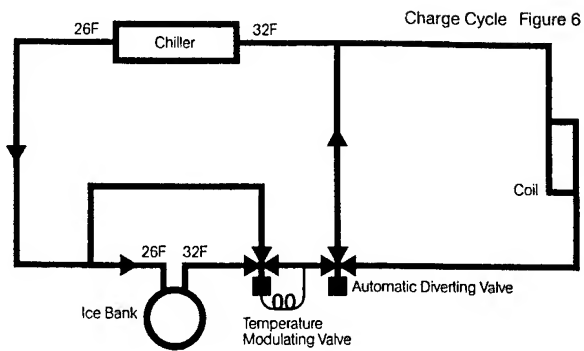


Figure 6

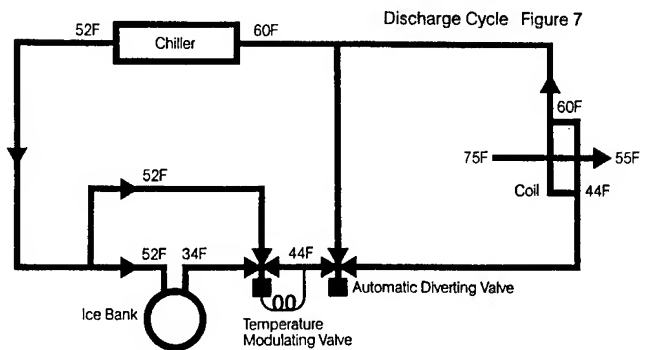


Figure 7

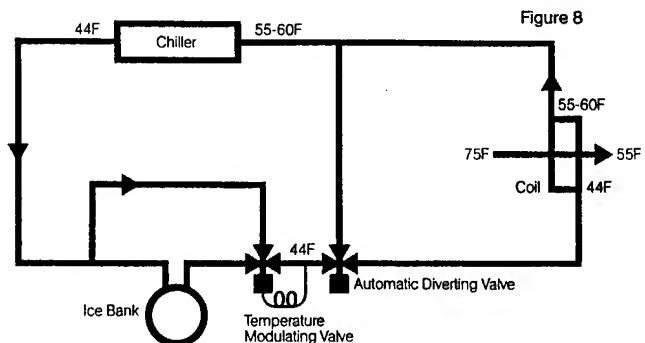


Figure 8

The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's DOWTHERM® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 4701EC4

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM

ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	132000.
B. SIOH	\$	7260.
C. DESIGN COST	\$	7920.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	132462.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	132462.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)	11.65	\$	12502.
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	145648.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ 145648.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33) \$ 0.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= .00

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 12502.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 145648.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.10  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 10.60

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	29,264	--	100
ECO	--	11,811	--	40
Savings (Baseline-ECO)	0	17,453	0	60

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 60 MMBtu/Yr X \$4.0141 /MMBtu = \$239 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$239 + \$0 = \$239 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$1,013 per year  
**Total: \$0 - \$1,013 = (\$1,013) per year**

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input. The calculations take into account multi-cell towers (part 7). The control sequence is:

- 0-25% load, fan 1, half speed cycling.
- 25-50% load, fan 1 half speed running, fan 2 half speed cycling.
- 50-75% load, fan 1 full speed cycling, fan 2 half speed running.
- 75-100% load, fan 1 full speed running, fan 2 full speed cycling.

kWh per bin, for % design loads less than 25% load = (fan 1 power kW) \* 14% \* (% design load / 25) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 25% to 50% load = (fan 1 power kW \* 14% \* 4 hours per bin \* days per month) \* (fan 2 power kW \* 14% \* ((% design load - 25) / 25) \* 4 hours per bin \* days per month)

kWh per bin, for % design loads 50% to 75% load = (fan 2 power kW \* 14% \* 4 hours per bin \* days per month) \* (fan 1 power kW \* ((% design load - 50) / 25) \* 4 hours per bin \* days per month)

kWh per bin, for % design loads 75% to 100% load = (fan 1 power kW \* 4 hours per bin \* days per month) + (fan 2 power kW \* ((% design load - 75) / 25) \* 4 hours per bin \* days per month)

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = (total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

<b>CENTRAL PLANT</b>		<b>4701</b>
<b>DESIGN CONDITIONS</b>		
– WBT (DB, DEG F)		78
– WATER FLOW (gpm)		1650
– CNWR (DEG F)		95
– CNWS (DEG F)		85
ASSUMPTION LIQUID TO GAS RATIO		2
– AIR FLOW (LBS/MIN)		6847.5
HEAT REJECTION CAPACITY (Btu/min)		136950
DELTA ENTHALPY (Btu/lb)		20
DESIGN ENTHALPY (Btu/lb)		41.58
TOTAL ENTHALPY		61.58
EXIT AIR WB (LOOK UP)		93.9
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)		15.1
100% DESIGN CFM @ WB		103397
<b>MOTOR DATA</b>		
– FAN 1 POWER (kW)		10.5
– FAN 2 POWER (kW)		10.5
– FAN 3 POWER (kW)		12.0
– FAN 4 POWER (kW)		12.0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET – BULB AVERAGES (4 hour bins)						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	78
MAY	57.1	56.6	61.2	63.9	63	59.4	78
JUNE	66.8	66.6	69.9	71	70.5	68.2	78
JULY	70.8	70.9	74.5	76	74.9	72.6	78
AUGUST	66.9	67	71	72	71	68.5	78
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	78
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	78

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	41.58
MAY	24.53	24.21	27.28	29.23	28.57	26.06	41.58
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	41.58
JULY	34.77	34.86	38.14	39.57	38.52	36.37	41.58
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	41.58
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	41.58
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	41.58

COOLING PROFILE OF CENTRAL PLANTS							PEAK
	1-4	5-8	9-12	13-16	17-20	21-24	LOAD
							(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0	0.9	0.6	0.8	0	0	1465000
JUNE	0	0.9	0.6	0.8	0	0	4316000
JULY	0	0.9	0.6	0.8	0	0	4316000
AUGUST	0	0.9	0.6	0.8	0	0	4316000
SEPTEMBER	0	0.9	0.6	0.8	0	0	4316000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	22
MAY	1.9	1.9	1.7	1.6	1.7	1.8	23
JUNE	1.5	1.5	1.4	1.3	1.4	1.4	22
JULY	1.3	1.3	1.2	1.1	1.2	1.3	23
AUGUST	1.5	1.5	1.3	1.3	1.3	1.4	23
SEPTEMBER	1.6	1.6	1.5	1.4	1.5	1.6	22
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	23

% DESIGN LOAD							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	22
MAY	0.0	16.3	11.9	16.8	0.0	0.0	23
JUNE	0.0	59.5	43.5	60.1	0.0	0.0	22
JULY	0.0	67.4	51.2	72.7	0.0	0.0	23
AUGUST	0.0	60.1	45.1	62.1	0.0	0.0	23
SEPTEMBER	0.0	57.0	40.9	56.2	0.0	0.0	22
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	23

SINGLE SPEED CONTROL (kWh)							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0	0	0	0	0	0	23
MAY	0	677	492	695	0	0	22
JUNE	0	2355	1724	2379	0	0	23
JULY	0	2789	2119	3010	0	0	23
AUGUST	0	2487	1866	2572	0	0	22
SEPTEMBER	0	2256	1620	2224	0	0	23
OCTOBER	0	0	0	0	0	0	0
TOTAL	0	10564	7820	10880	0	0	29264

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	0	23	9	24	0	0	
JUNE	0	1041	408	1074	0	0	
JULY	0	1582	694	1988	0	0	
AUGUST	0	1122	474	1241	0	0	
SEPTEMBER	0	915	339	877	0	0	
OCTOBER	0	0	0	0	0	0	
TOTAL	0	4683	1924	5204	0	0	11811

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-R. APR 85

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 4701EC5B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	16880.
B. SIOH	\$	929.
C. DESIGN COST	\$	1013.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	16940.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	16940.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	60.	\$ 239.	11.37	2719.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		60.	\$ 239.		\$ 2719.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      11.65

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -11801.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -11801.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 897.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -774.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -9083.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -0.54  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -21.89

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.  
 It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	3	4,605	0	16

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 16 MMBtu/Yr X \$4.0141 /MMBtu = \$63 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$63 + \$0 = \$63 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 3 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$64 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$64 - \$0 = \$64 per year**

[ECO-SHT.WK3]

# **HIGH EFFICIENCY MOTOR REPLACEMENT**

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR
730	CWP-1	150.0	179.0	147.0	0.87	460	90.19%	95.00%	5.73	2641	15120	\$330
	CWP-2	150.0	179.0	148.0	0.91	460	86.22%	95.00%	11.50	1873	21539	\$542
	CNWP-1	50.0	118.0	107.0	0.98	230	80.97%	93.00%	6.67	2641	17629	\$385
	CNWP-2	50.0	118.0	107.0	0.99	230	80.15%	93.00%	7.27	468	3405	\$203
	CNWP-3	NI	NI	NI								
	CTM-1	30.0	71.4	70.7	0.93	230	84.60%	92.40%	2.61	702	1834	\$81
	CTM-2	30.0	71.4	71.0	0.87	230	90.44%	92.40%	0.58	702	405	\$18
	HWP-1	50.0	125.0	117.5	0.87	230	86.10%	93.00%	3.51	3624	12722	\$250
	HWP-2	50.0	125.0	118.0	0.87	230	86.10%	93.00%	3.53	3624	12776	\$251
	<b>DEMAND CREDIT</b>			<b>\$888</b>		<b>MMBtu 292</b>		<b>TOTAL</b>	<b>41</b>		<b>85430</b>	<b>\$2,058</b>
914	CWP-1	40.0	48.0	41.3	0.87	460	89.69%	93.00%	1.14	3672	4178	\$82
	CNWP-1	15.0	19.0	14.4	0.82	460	90.15%	90.20%	0.01	3672	23	\$0
	CTM-1	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	CTM-2	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	HWP-1	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33
	HWP-2	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34
	<b>DEMAND CREDIT</b>			<b>\$111</b>		<b>MMBtu 30</b>		<b>TOTAL</b>	<b>5</b>		<b>8932</b>	<b>\$233</b>
2812	CWP-1	20.0	27.0	23.0	0.77	460	90.07%	91.00%	0.16	3672	586	\$11
	CNWP-1	25.0	31.5	26.5	0.82	460	91.18%	91.70%	0.11	3672	394	\$8
	CTM-1	15.0	18.6	18.6	0.87	460	86.79%	90.20%	0.56	1167	655	\$21
	HWP-1	7.5	21.6	18.5	0.87	230	74.74%	88.50%	1.33	5163	6888	\$123
	HWP-2	7.5	21.6	19.0	0.87	230	74.74%	88.50%	1.37	3672	5031	\$98
	<b>DEMAND CREDIT</b>			<b>\$76</b>		<b>MMBtu 46</b>		<b>TOTAL</b>	<b>4</b>		<b>13554</b>	<b>\$261</b>
3442	CWP-1	60.0	73.0	63.0	0.84	460	91.62%	94.50%	1.40	3672	5158	\$101
	CWP-2	60.0	73.0	63.4	0.84	460	91.62%	94.50%	1.41	3672	5191	\$101
	CNWP-1	40.0	52.0	41.0	0.78	460	92.34%	93.00%	0.20	3672	721	\$14
	CNWP-2	40.0	52.0	35.8	0.78	460	92.34%	93.00%	0.17	3672	629	\$12
	CTM-1	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-2	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-3	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-4	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	<b>DEMAND CREDIT</b>			<b>\$90</b>		<b>MMBtu 44</b>		<b>TOTAL</b>	<b>4</b>		<b>12880</b>	<b>\$266</b>
4701	CWP-1	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CWP-2	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CNWP-1	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CNWP-2	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CTM-1	20.0	24.6	18.2	0.87	460	87.50%	91.00%	0.55	650	361	\$17
	CTM-2	15.0	19.2	16.5	0.87	440	87.90%	90.20%	0.32	650	206	\$10
	<b>DEMAND CREDIT</b>			<b>\$65</b>		<b>MMBtu 16</b>		<b>TOTAL</b>	<b>3</b>		<b>4605</b>	<b>\$128</b>
5676	HCP-1	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	HCP-2	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	10.5	9	0.79	460	84.66%	88.50%	0.29	1160	337	\$11
	<b>DEMAND CREDIT</b>			<b>\$94</b>		<b>MMBtu 83</b>		<b>TOTAL</b>	<b>4</b>		<b>24287</b>	<b>\$427</b>
5678	HCP-1	2.0	6.5	5.9	0.83	208	76.76%	84.00%	0.20	7296	1445	\$24
	HCP-2	2.0	6.5	5.7	0.83	208	76.76%	84.00%	0.19	7296	1396	\$23
	HCP-3	1.5	4.8	4.5	0.83	230	70.51%	84.00%	0.34	7296	2474	\$41
	HCP-4	2.0	6.3	5.8	0.83	230	71.62%	84.00%	0.39	7296	2878	\$48
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	11	9.6	0.75	460	85.12%	88.50%	0.26	1139	293	\$10
	<b>DEMAND CREDIT</b>			<b>\$64</b>		<b>MMBtu 49</b>		<b>TOTAL</b>	<b>3</b>		<b>14412</b>	<b>\$262</b>



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 4701EC6

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	17229.
B. SIOH	\$	948.
C. DESIGN COST	\$	1034.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	17290.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	17290.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	16.	\$ 63.	11.37	717.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		16.	\$ 63.		\$ 717.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	64.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	746.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	746.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	236.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		.06
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 127.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 1462.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .08  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 136.12

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-7  
**SYSTEM MODIFICATION:** INSTALL INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-7, install instrumentation to facilitate efficient operation of boiler plant. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	0	61	61

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	61 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$178 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$178</b>	<b>=</b>	<b>\$178 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0		per year
Maintenance:	= (-)		\$463		per year
<b>Total:</b>		<b>\$0 -</b>	<b>\$463</b>	<b>=</b>	<b>(\$463) per year</b>

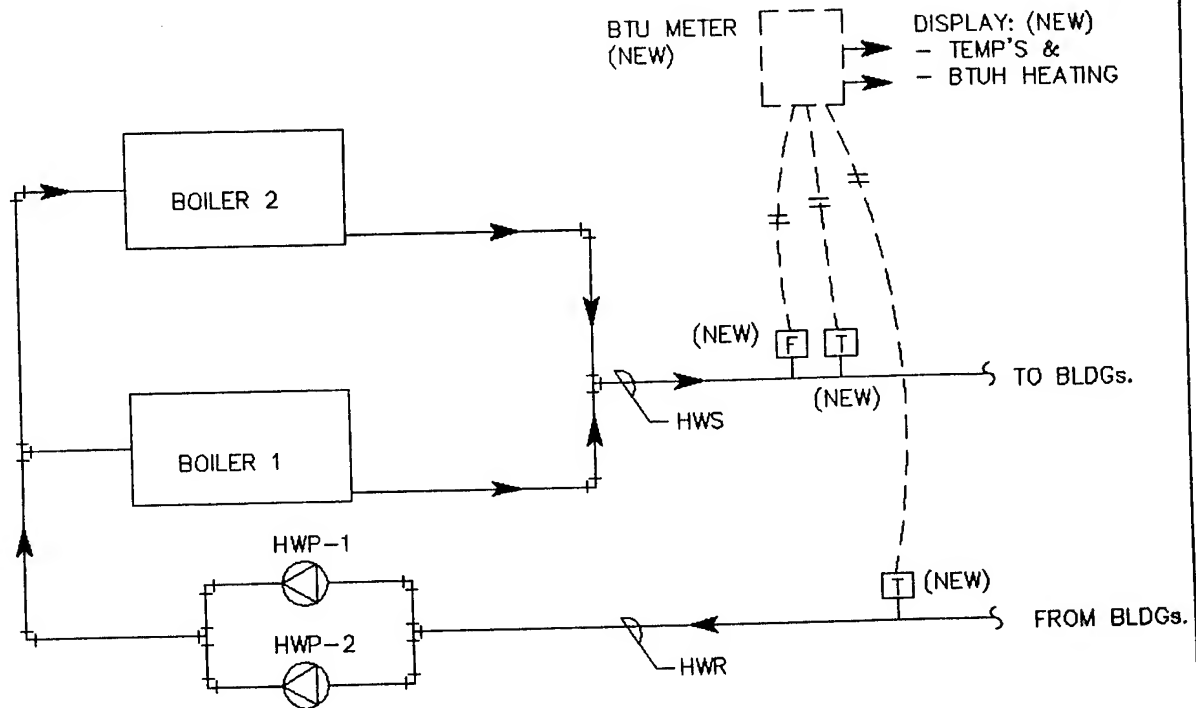
[ECO-SHT.WK3]

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (1%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS STANDBY SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0	0	
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	51.62	\$150.74
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.82	\$160.09
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	\$159.27
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0		
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0		
					TOTAL			2160	160.99	\$470.10
6003	1	STEAM-12	KEWANEE	L39-350-605	11.72	9.41	0.0941	0		
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0		
	3	STEAM-12	KEWANEE	L38-350-605	11.72	9.37	0.0937	720	67.45	\$196.96
					TOTAL			720	67.45	\$196.96
730	1	STEAM-12	KEWANEE	CAT #71286-KX	7.75	6.16	0.0616	0		
	2	STEAM-12	KEWANEE	CAT #71286-KX	7.75	6.16	0.0616	720	44.34	\$129.47
	3	STEAM-12	KEWANEE	CAT #71286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANEE	CAT #71280-KG-06	2.66	2.11	0.0211	0		
					TOTAL			1440	88.84	\$259.43
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3562	1.80	1.40	0.0140	0		
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.77	0.0277	0		
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.62	\$60.21
					TOTAL			720	20.62	\$60.21
5878	1	HW	AMERICAN STANDARD	PF 515	2.44	1.80	0.0180	720	12.93	\$37.76
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
					TOTAL			720	12.93	\$37.76
5878	1	HW	BRUNHAM	PF 514	2.27	1.50	0.0150	720	10.79	\$31.50
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
					TOTAL			720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.61	1.29	0.0129	0		
	2	HW	RAY-PAK	EA 200T8	1.61	1.22	0.0122	0		
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0		
					TOTAL			720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	0		
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
					TOTAL			720	60.73	\$177.33

[BOILERS.WK3]

# ECO-7, INSTRUMENTATION FOR BOILER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[B-ECO-7.DWG]

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B4701EC1

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER INSTRUMENTATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	7720.
B. SIOH	\$	425.
C. DESIGN COST	\$	464.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	7748.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	7748.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	61.	\$ 177.	12.48	2213.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		61.	\$ 177.		\$ 2213.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-463.
(1) DISCOUNT FACTOR (TABLE A)	9.11		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	-4218.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-4218.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	730.	
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -286.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -2005.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -26  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -27.12

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 10  
**SYSTEM MODIFICATION:** OXYGEN TRIM FOR BURNERS  
**SYSTEMS TO MODIFY:** BOILER 1, 2, AND 3

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-10, install oxygen trim for burners.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	9,596	9,596
ECO	--	--	9,436	9,436
Savings (Baseline-ECO)	0	0	160	160

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	160 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$467 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$467</b>	<b>=</b>	<b>\$467 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$0 per year
Maintenance:	=	(-)			\$1,799 per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$1,799</b>	<b>=</b>	<b>(\$1,799) per year</b>

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 4701 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7875.
PEAK DAY GAS CONSUMP., 1000 CU FT	99.
ELECTRICAL CONSUMPTION, KWH	305028.
PEAK KW DEMAND (15 MIN BASIS)	396.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	305028.
ON-PEAK KW DEMAND (15 MIN BASIS)	396.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	1873
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

## SYSTEM C1 SUMMER HW LOADS

\*\* TOTAL \*\*

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	1720.
PEAK DAY GAS CONSUMP., 1000 CU FT	16.
ELECTRICAL CONSUMPTION, KWH	0.
PEAK KW DEMAND (15 MIN BASIS)	0.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	0.
ON-PEAK KW DEMAND (15 MIN BASIS)	0.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
BOILER OPERATING HOURS	
BOILER 1	647
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

## CENTRAL PLANT 4701 BOILER ECO-4

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7733.
PEAK DAY GAS CONSUMP., 1000 CU FT	97.
ELECTRICAL CONSUMPTION, KWH	305028.
PEAK KW DEMAND (15 MIN BASIS)	396.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	305028.
ON-PEAK KW DEMAND (15 MIN BASIS)	396.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	1873
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 4701 BOILER ECO-4

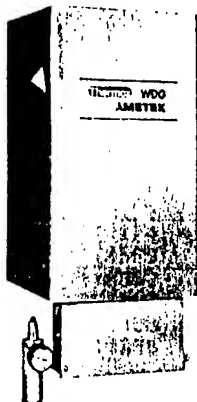
\*\* TOTAL \*\*

## SYSTEM C1 SUMMER HW LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	1703.
PEAK DAY GAS CONSUMP., 1000 CU FT	16.
ELECTRICAL CONSUMPTION, KWH	0.
PEAK KW DEMAND (15 MIN BASIS)	0.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	0.
ON-PEAK KW DEMAND (15 MIN BASIS)	0.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
BOILER OPERATING HOURS	
BOILER 1	642
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# SPECIFICATIONS — AIR-MIZER II SYSTEM

## SENSOR



**Nominal Dimensions:** 14 1/8" H x 10 1/4" W x 10" D (37.2 x 26 x 25.4 cm)

**Enclosure:** Weather resistant—S.S. case, nickel plated carbon steel base

**Weight:** 55 pounds (25 kg)

**Accuracy:**  $\pm 1\%$  of net excess oxygen

**Repeatability:**  $\pm 0.2\%$  of measured value

**Response:** 90% of full scale in less than 5 seconds

**Drift:** Less than 0.1% of sensor cell output per month

**Ambient Temperatures:**  $-5$  to  $+175^{\circ}\text{F}$  ( $-20.5$  to  $+79^{\circ}\text{C}$ )

**Sample Temperatures:** Up to  $1300^{\circ}\text{F}$  ( $704^{\circ}\text{C}$ ) with standard probe

**Sample Flow Rate:** 0.1 to 120 scfh (0.47 to 56.65 liters/minute)

**Air Aspirator Requirements:** 10 to 20 scfh (4.72 to 14.16 liters/min) at 15-100 psi (1.05 to 7.037 kg/cm<sup>2</sup>) (Aspirator air regulator furnished with sensor normally set at 2-7 psi; 0.14 - 0.49 kg/cm<sup>2</sup>)

**Calibration:** With analyzed oxygen in nitrogen sample. Calibration port provided.

## CONTROL UNIT

**Nominal Dimensions:** 12 1/8" H x 10 1/8" W x 9 1/8" D (32.1 x 27.6 x 23.2 cm)

**Enclosure:** Wall/panel mounted—meets the requirements for NEMA 4 areas

**Weight:** 22 pounds (10 kg)

**Temperature Control:** On-Off by microprocessor ( $\pm 1^{\circ}\text{C}$ )

**Linearization:** 256 segments from 20% to 0.2% O<sub>2</sub>, (218 from 10% to 0.2%), by microprocessor

**Controller Action:** On-Off—"On" time adjustable 2-20 seconds. "Off" time adjustable 2-60 seconds.

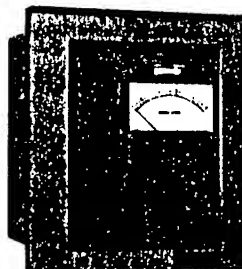
Deadband:  $\pm 0.25\%$  oxygen.

LED's indicate motor driving.

Will not allow decrease in air when O<sub>2</sub> is below 0.5% oxygen.

Air flow will increase to  $+15\%$  max. if O<sub>2</sub> level is above 12%.

**Setpoint:** 0 to 10% oxygen by either of: A. Two banks of 5 slide pots, (Dual Fuel) selectable by slide switch; proper pot or pots connected to processor by switch in actuator. B. Manual pot on panel A or B selected by Remote/Local switch on panel. Setpoint indicated by edge reading meter (0-10%)



**Manual Control:** Manual/Auto switch and Increase—decrease push buttons (Spring return switch inside control unit can override all control actions in the event of processor failure).

**Ready Indicator:** On at temperature set point. Off below temperature set point. Flashes above temperature set point. O<sub>2</sub> Control in "manual" when below set point.

**Oxygen Scale:** 20.9 to 0.1% O<sub>2</sub>, Logarithmic

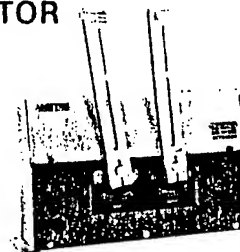
**Alarms:** High and Low O<sub>2</sub> adjustable 0.2 to 20%. RTD Failure (shuts down temperature control, and puts O<sub>2</sub> control in "manual").

**Increase Air Override:** Contact closure from optional combustibles or smoke detector alarm will cause increase in air signal on each control pulse regardless of O<sub>2</sub> vs. O<sub>2</sub> setpoint relationship. Once combustibles contact opens, normal control will resume. This maintains air flow at a level where maximum allowable combustibles or smoke is not exceeded.

**Ambient Temperature Limits:**  $32^{\circ}\text{F}$  to  $140^{\circ}\text{F}$  ( $0$  to  $+60^{\circ}\text{C}$ )

**Recorder Output:** 0-100 mv = 0-20% O<sub>2</sub> Linear (0-50 mv = 0-10%) Other current or voltages outputs optional

## ACTUATOR



**Overall Size:** 17 1/4" L x 4" W x 10 1/4" H (44.5 x 10.2 x 26 cm)

**Weight:** 16.5 pounds (7.5 kg)

**Angular Travel (Input Arm):**  $60^{\circ}$

**Linear Link Travel:** Adjustable 4" to 10" at 4" to 10" Radius (10.2 to 25.4 cm at 10.2 to 25.4 cm Radius)

**Linear Link Force:** 100 pounds at 4" Radius (45.5 kg at 10.2 cm Radius)

70 pounds at 6" Radius (31.8 kg at 15.2 cm Radius)

40 pounds at 10" Radius (18.2 kg at 25.4 cm Radius)

**Case:** Suitable for areas requiring NEMA 2 equipment (Drip proof indoor)

**Correction:**  $-15\%$  to  $+15\%$  (.85 to 1.15 gain) of normal air flow

**Speed:** 60 seconds from  $-15\%$  to  $+15\%$  correction (max.)

**Load Indication:** 9 position shorting switch tied to input arm

**Brake:** Internal brake will hold load at any above rated force without "coasting"

**Ambient Temperature Limits:**  $0^{\circ}\text{F}$  to  $160^{\circ}\text{F}$  ( $-18$  to  $+71^{\circ}\text{C}$ )



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 4701EC10

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER O2 TRIM CONTROL

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	23572.
B. SIOH	\$	1297.
C. DESIGN COST	\$	1415.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	23656.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	23656.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	160.	\$ 467.	12.48	5831.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		160.	\$ 467.		\$ 5831.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-1799.
(1) DISCOUNT FACTOR (TABLE A)	9.11		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	-16389.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-16389.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1924.	
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F= _____			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -1332.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -10558.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.45  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -17.76

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:**  
**SYSTEM MODIFICATION:** STACK ECONOMIZERS  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

ECO- 12

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-12, install stack economizer for boilers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	9,596	9,596
ECO	--	--	9,507	9,507
Savings (Baseline-ECO)	0	0	89	89

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	89 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$260 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$260</b>	<b>=</b>	<b>\$260 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 4701 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7875.
PEAK DAY GAS CONSUMP., 1000 CU FT	99.
ELECTRICAL CONSUMPTION, KWH	305028.
PEAK KW DEMAND (15 MIN BASIS)	396.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	305028.
ON-PEAK KW DEMAND (15 MIN BASIS)	396.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	1873
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 4701 BASELINE-2

\*\* TOTAL \*\*

SYSTEM C1 SUMMER HW LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	1720.
PEAK DAY GAS CONSUMP., 1000 CU FT	16.
ELECTRICAL CONSUMPTION, KWH	0.
PEAK KW DEMAND (15 MIN BASIS)	0.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	0.
ON-PEAK KW DEMAND (15 MIN BASIS)	0.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
BOILER OPERATING HOURS	
BOILER 1	647
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 4701 BOILER ECO-6

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	7800.
PEAK DAY GAS CONSUMP., 1000 CU FT	98.
ELECTRICAL CONSUMPTION, KWH	305028.
PEAK KW DEMAND (15 MIN BASIS)	396.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	305028.
ON-PEAK KW DEMAND (15 MIN BASIS)	396.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	1873
CHILLER 2	1873
BOILER OPERATING HOURS	
BOILER 1	1205
BOILER 2	0
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

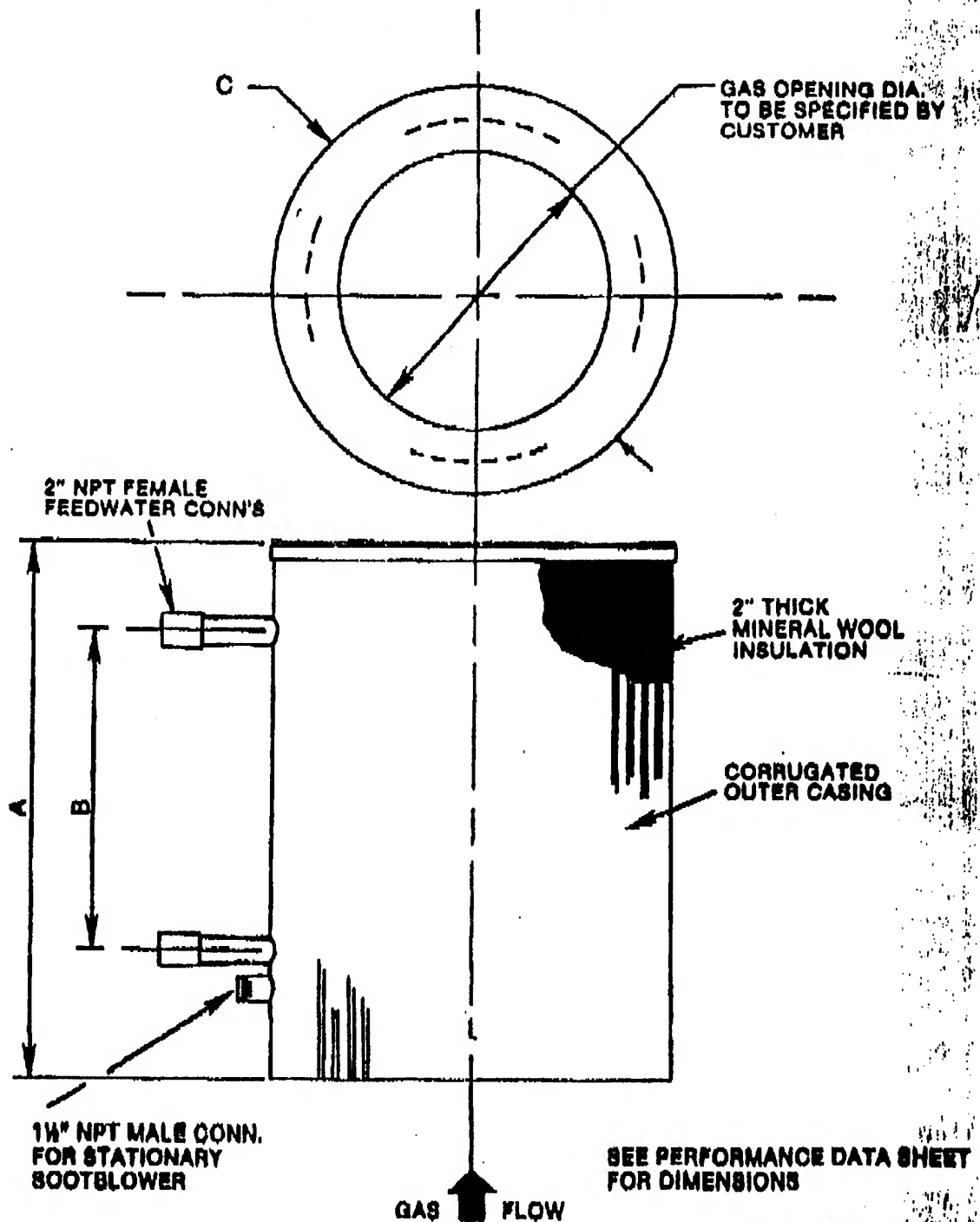
CENTRAL PLANT 4701 BOILER ECO-6

\*\* TOTAL \*\*

SYSTEM C1 SUMMER HW LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	1708.
PEAK DAY GAS CONSUMP., 1000 CU FT	16.
ELECTRICAL CONSUMPTION, KWH	0.
PEAK KW DEMAND (15 MIN BASIS)	0.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	0.
ON-PEAK KW DEMAND (15 MIN BASIS)	0.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
BOILER OPERATING HOURS	
BOILER 1	643
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# Kentube cylindrical FUEL ECONOMIZER



**Kentube**

4150 South Elwood • Tulsa, Oklahoma 74107  
918/448-4581 • Telex: 49-2353

\*\*\*OF\*\*\*  
CUSTOMER  
EMC Engineers  
PROPOSAL 318-10351-0-0  
RUN 00

KENTUBE  
4150 S. ELWOOD  
TULSA, OKLAHOMA

PRINTED 04/10/91  
TIME 09 HRS 10 MINS  
CUST. REFERENCE

# CYLINDRICAL FUEL ECONOMIZER

MODEL 100930

## OVERALL PERFORMANCE

### COUNTER CURRENT FLOW

FLUID CIRCULATED IN TUBES IS WATER  
HEAT EXCHANGED 97907. BTU/HR  
U EXTERNAL 4.811 BTU/HR-SQFT-F  
LMTD 150.1 DEG F

## PERFORMANCE SPECIFICATIONS

	TUBE SIDE ↓	GAS SIDE ↑	
FLOW RATE	2070.	2474.	LB/HR
TEMP IN	180.0	450.0	DEG F
TEMP OUT	227.2	301.1	DEG F
PRES IN	150.0 PSIG	14.7	PSIA
PRES DROP	.0 PSI	.19	IN WATER

## OVERALL CONSTRUCTION

### VERTICAL GAS FLOW DIMENSIONS

DIM A (HEIGHT) 5'-3/4"  
DIM B (NOZ C-C) 3'-3 3/8"  
DIM C (DIAMETER) 2'-1 1/2"  
DRAWING NO V-1  
BOOT BLOWERS ARE BUILT IN  
NOZZLE SIZE 2.0 IN  
SURFACE AREA 134. SQFT  
LIQUID WEIGHT 70. LB  
UNIT WEIGHT(DRY) 742. LB

## CONSTRUCTION SPECIFICATIONS TUBE SIDE

DESIGN PRESSURE 490. PSI  
TEST PRESSURE 735. PSI  
DESIGN TEMPERATURE 700. DEG  
TUBE OUTSIDE DIA 2.000 IN  
MATERIAL C/STL  
FIN THICKNESS .060 IN  
PITCH 3.00 FINS/  
MATERIAL C/STL  
INSULATION  
MATERIAL MINERAL WOOL  
THICKNESS 2.0 IN



4150 S. Elwood  
Tulsa, Oklahoma 74107  
Phone: (918) 446-4561  
FAX: (918) 446-6340

# QUOTATION

T O	<b>EMC Engineers</b> 2750 South Wadsworth Blvd. Denver, CO 80227  Attention: Mr. Dennis Jones	QUOTATION DATE	YOUR REFERENCE		OUR REFERENCE
		04/10/91			318-10351-0-0
		SHIPPING ESTIMATE	TERMS		PAGE 1 OF 2
		8 Weeks*	Net 30 Days		
		SHIPPING DESTINATION	P.O.B. Kentube Shop**		

THANK YOU FOR YOUR INQUIRY. WE APPRECIATE THE OPPORTUNITY TO PROPOSE THE FOLLOWING:

ITEM	QUANTITY	DESCRIPTION	UNIT AMOUNT	AMOUNT
	4	<p>Kentube RETROMISER Fuel Economizer Cylindrical Model 100930, in accordance with the attached performance specifications.</p> <p><b>DESIGN FEATURES</b></p> <p>Finned tube unit; 3 Fins per inch; Vertical gas flow; Counter-current flow Fuel type: NATURAL GAS.</p> <p>Estimated Shipping Weight - 742. LBS.</p> <p>Pressure parts to Section I of the ASME Boiler &amp; Pressure Vessel Code.</p> <p>External 2" insulation with weatherproof, corrugated casing is included.</p> <p>Threaded drain and vent connections included.</p> <p>Kentube manually operated sootblower, integral with unit, included. Requires 85 psig to 250 psig supply pressure.</p>	4	\$ 12044.

**ENCLOSURES**

cc: Ted D. Miller Associates

NOTE: All shipping estimates are based on "after receipt of order" and "after final print approvals" as required. Shipments can often be improved upon request. Please contact Kentube. Prices firm for 30 days and subject to change thereafter. No provision is made for Federal, State or Municipal taxes. All orders are subject to acceptance or rejection by the Credit Department of Kentube and to the Terms of Sale attached.

YOUR REPRESENTATIVE IS: Ted D. Miller Associates 2140 South Ivanhoe Denver, CO 80222	YOUR ORDER WILL RECEIVE OUR PROMPT ATTENTION KENTUBE FABRICATED PRODUCTS <i>Larry Wolfenbarger</i> Larry Wolfenbarger Product Sales Engineer
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# QUOTATION

TO	EMC Engineers	/318-10351-0-0
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PAGE	2	OF	2
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ITEM	QUANTITY	DESCRIPTION	UNIT AMOUNT	AMOUNT
<p align="center"><b>SUGGESTED ACCESSORIES</b> (Quantities below are for each unit)</p>				
1		Bolted access manway in casing, approximately 16" square, carbon steel construction.	\$ 300.	\$ 300.
1		1/2" Threaded connection for safety relief valve on header.	\$ 100.	\$ 100.
1		1/2" Threaded safety relief valve, Kunkle series 927.	\$ 555.	\$ 555.
<p>** All prepaid and bill shipments will be at the billable freight amount plus a service charge of 10%. A service charge is not required for collect shipments or third party billing.</p>				
<p align="center">***** * KENTUBE is a member of the * * AMERICAN BOILER MANUFACTURERS ASSOCIATION * *****</p>				



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 4701EC11  
 LCCID 1.035  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3  
 PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: ECONOMIZER AIR PREHEAT  
 ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	44359.
B. SIOH	\$	2440.
C. DESIGN COST	\$	2662.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	44515.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	44515.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	77.	\$ 225.	17.52	3939.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		77.	\$ 225.		\$ 3939.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	0.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	0.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	0.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1300.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 225.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 3939.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .09  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 197.98

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 4701  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 14  
**SYSTEM MODIFICATION:** NEW CHW & CW PUMPS TO MATCH LOAD  
**SYSTEMS TO MODIFY:** NEW CHW & CW PUMPS

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-14, install new pump to match load requirements. It was estimated that the electrical energy can be saved by installing smaller pumps to match the load, based on the pump operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	0	0
ECO	--	--	0	0
Savings (Baseline-ECO)	0	50,401	0	172

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	172 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$690 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$690 +</b>	<b>\$0</b>	<b>=</b>	<b>\$690 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

[ECO-SHT.WK3]

**E M C ENGINEERS, INC.**

Denver • Colorado Springs • Atlanta • West Germany

JOB FL-SILL CENTRAL PLANT 3002.000  
 SHEET NO. 1 OF 1  
 CALCULATED BY KC DATE 4-3-91  
 CHECKED BY CEL DATE 4-18-91  
 SCALE CHILLER ECO-14

ADDITIONAL PUMPS FOR CHW & CNW SYSTEM BLDG. 4701

CHILLED WATER:  $FLOW = \frac{TONS \times 12000}{\Delta T \times 500} = \frac{305 \times 12000}{(53-43) \times 500} = 732 \text{ GPM} @ 100 \text{ TDH-FT}$   
 $BHP = \frac{TDH-FT \times GPM}{3960 \times 0.8} = \frac{100 \times 732}{3960 \times 0.8} = 23.11 \text{ BHP}$   
 $MOTOR \text{ HP} = \frac{BHP}{\% \text{ EFF (PUMP)}} = \frac{23.11}{80\%} = 28.88 \text{ HP}$   
 $KW = \frac{HP \times 0.746}{\% \text{ EFF (MOTOR)}} = \frac{28.9 \times 0.746}{92\%} = 23.42 \text{ KW}$

CONDENSING WATER:

$FLOW = 825 \text{ GPM} @ 52 \text{ TDH-FT (DESIGN DWS.)}$   
 $BHP = \frac{TDH-FT \times GPM}{3960 \times 0.8} = \frac{52 \times 825}{3960 \times 0.8} = 13.54 \text{ BHP}$   
 $MOTOR \text{ HP} = \frac{BHP}{\% \text{ EFF (PUMP)}} = \frac{13.54}{80\%} = 16.92 \text{ HP}$   
 $KW = \frac{HP \times 0.746}{\% \text{ EFF (MOTOR)}} = \frac{16.92 \times 0.746}{91.7\%} = 13.77 \text{ KW}$

PEAK COOLING LOAD IS 6.6 MMBtu/h

275 TONS CHILLER CAN SUPPLY =  $275 \times 12000 = 33 \text{ MMBtu/h}$ % PERCENT OF LOAD IS =  $\frac{3.3 \text{ MMBtu/h}}{6.6 \text{ MMBtu/h}} = 50\%$ 

FROM PC-CUBE BASE RUN HRS @ 50% IS 1786 HRS/YR

EXISTING ENERGY USAGE: 50 HP @ 92.73% EFF  
30 HP @ 88.87% EFF

$$KW = \frac{50 \text{ HP} \times 0.746 \text{ KW/HP}}{92.73\%} + \frac{30 \text{ HP} \times 0.746 \text{ KW/HP}}{88.87\%} = 65.41 \text{ KW}$$

NEW ENERGY USAGE:

$$KW \text{ SAVINGS} = 65.41 - 23.42 - 13.77 = 28.22 \text{ KW}$$

$$\$ \text{ SAVINGS} = 28.22 \text{ KW} \times 1786 \text{ HRS} \times 0.0137 \text{ \$/KWH}$$

$$= \$690./\text{YR}$$

OR =  $\frac{1 \text{ KWH}}{50401 \text{ KWH/YR}}$  OR  $\frac{6 \text{ OF MMBtu}}{172 \text{ MMBtu/YR}}$



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 4701EC14

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: PUMP TO MATCH LOAD

ANALYSIS DATE: 04-15-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	20064.
B. SIOH	\$	1104.
C. DESIGN COST	\$	1204.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	20135.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	20135.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	172.	\$ 690.	11.37	7850.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		172.	\$ 690.		\$ 7850.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      11.65

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 2591.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 690.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 7850.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .39  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 29.16

CENTRAL PLANT 5676

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-3  
**SYSTEM MODIFICATION:** CHILLER REPLACEMENT  
**SYSTEMS TO MODIFY:** CHILLER 1

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-3, renovate or replace existing chillers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	165	299,000	--	1,020
ECO	69	162,000	--	553
Savings (Baseline-ECO)	96	137,000	0	468

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 468 MMBtu/Yr X \$4.0141 /MMBtu = \$1,877 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$1,877 + \$0 = \$1,877 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 96 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$2,059 per year  
 Maintenance: = (-) \$3,000 per year  
 Total: \$2,059 - \$3,000 = (\$941) per year

PC-CUBE VERSION 2.0.3

## CENTRAL PLANT 5676 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13463.
PEAK DAY GAS CONSUMP., 1000 CU FT	137.
ELECTRICAL CONSUMPTION, KWH	298696.
PEAK KW DEMAND (15 MIN BASIS)	165.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	298696.
ON-PEAK KW DEMAND (15 MIN BASIS)	165.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2057
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5676 CHILLER ECO-3

\*\* TOTAL \*\*

SYSTEM C1 NORMAL HEATING AND COOLING W/CHILLER IMPROVEMENT 90% EFF

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13463.
PEAK DAY GAS CONSUMP., 1000 CU FT	137.
ELECTRICAL CONSUMPTION, KWH	160907.
PEAK KW DEMAND (15 MIN BASIS)	69.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	160907.
ON-PEAK KW DEMAND (15 MIN BASIS)	69.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2057
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C5676EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER REPLACEMENT

ANALYSIS DATE: 04-09-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	89403.
B. SIOH	\$	4918.
C. DESIGN COST	\$	5365.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	89717.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	89717.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	468.	\$ 1877.	11.37	21340.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		468.	\$ 1877.		\$ 21340.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-941.
(1) DISCOUNT FACTOR (TABLE A)	11.65		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	-10963.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-10963.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)		\$	7042.
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ 936.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 10378.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .12  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 95.86

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	250	0	0	0

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$0 + \$0 = \$0 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 250 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$5,361 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$5,361 - \$0 = \$5,361 per year**

[ECO-SHT.WK3]

# A new application of an old idea that can cut air conditioning energy costs in half.

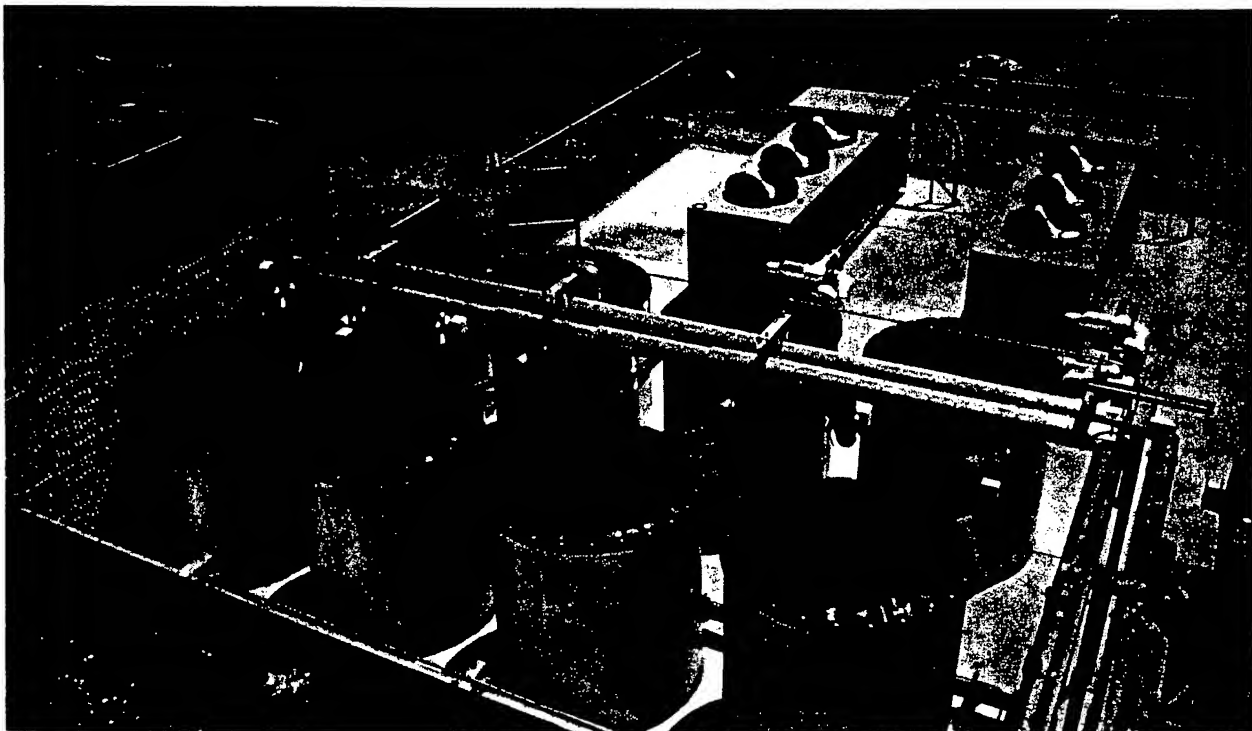
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes—90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.

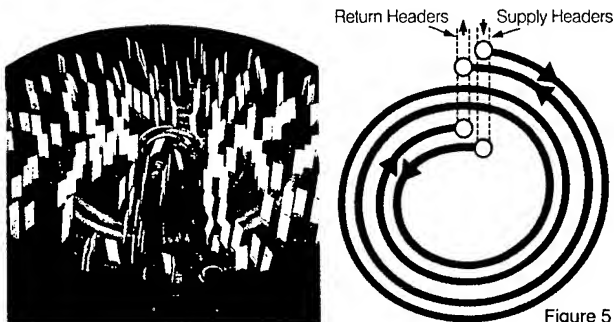


Figure 5

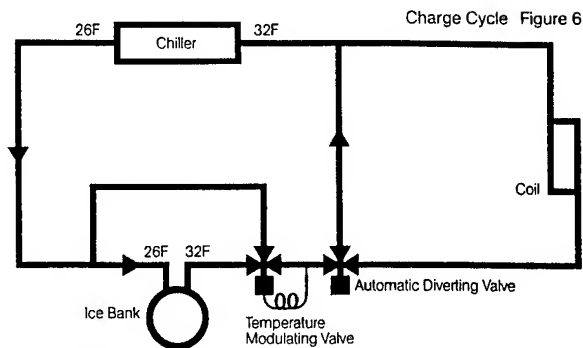
Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

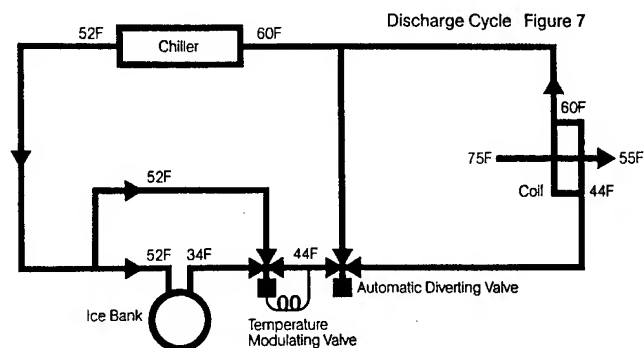
During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.



Charge Cycle Figure 6



Discharge Cycle Figure 7

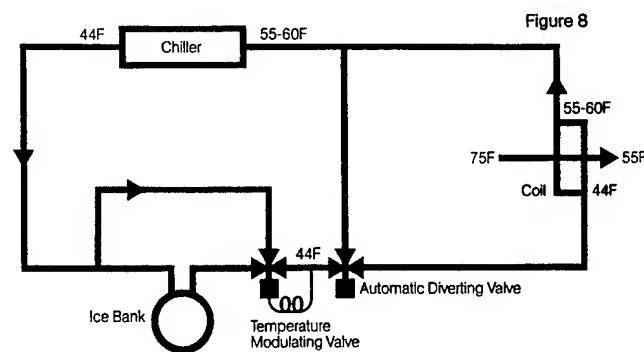


Figure 8

The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's Dowtherm® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 5676EC4  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM  
 ANALYSIS DATE: 04-18-91 ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$ 40800.
B. SIOH	\$ 2244.
C. DESIGN COST	\$ 2448.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$ 40943.
E. SALVAGE VALUE COST	-\$ 0.
F. TOTAL INVESTMENT (1D-1E)	\$ 40943.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$ 5361.
(1) DISCOUNT FACTOR (TABLE A)	11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$ 62456.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$ 62456.
D. PROJECT NON ENERGY QUALIFICATION TEST	
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$ 0.
A IF 3D1 IS = OR > 3C GO TO ITEM 4	
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=	.00
C IF 3D1B IS = > 1 GO TO ITEM 4	
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY	

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 5361.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 62456.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.53  
 (IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 7.64

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(A)  
**SYSTEM MODIFICATION:** TWO SPEED FANS FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	6,497	--	22
ECO	--	2,397	--	8
Savings (Baseline-ECO)	0	4,100	0	14

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	14 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$56 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$56 +</b>	<b>\$0</b>	<b>=</b>	<b>\$56 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

$(\text{Total exit air design enthalpy minus average monthly enthalpy, part 2}) / (\text{entering air design enthalpy})$

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

$(\% \text{ load on plant, part 3} * \text{monthly peak load, part 3}) / (\text{Highest monthly peak load, part 3}) * (1 / \text{ratio of monthly enthalpy, part 4})$

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

$\text{kWh per bin} = (\text{total fan power kW}) * (\% \text{ design load, part 5} * 4 \text{ hours per bin} * \text{days per month})$

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input (part 7). The control sequence is:

- 0-50% load, fan 1, half speed cycling.
- 50-100% load, fan 1 full speed cycling.

kWh per bin, for % design loads less than 50% load = (fan 1 power kW) \* 14% \* (%design load / 50) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 50% to 100% load = ( fan 1 power kW \* ((% design load)/ 100) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT	5676
DESIGN CONDITIONS	
– WBT (DB, DEG F)	77
– WATER FLOW (gpm)	525
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	2
– AIR FLOW (LBS/MIN)	2178.75
HEAT REJECTION CAPACITY (Btu/min)	43575
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	40.57
TOTAL ENTHALPY	60.57
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	32899
MOTOR DATA	
– FAN 1 POWER (kW)	5.6
– FAN 2 POWER (kW)	0
– FAN 3 POWER (kW)	0
– FAN 4 POWER (kW)	0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET – BULB AVERAGES (4 hour bins)						DESIGN WB
	1–4	5–8	9–12	13–16	17–20	21–24	
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	77
MAY	57.1	56.6	61.2	63.9	63	59.4	77
JUNE	66.8	66.6	69.9	71	70.5	68.2	77
JULY	70.8	70.9	74.5	76	74.9	72.6	77
AUGUST	66.9	67	71	72	71	68.5	77
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	77
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	77

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	40.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	40.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	40.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	40.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	40.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	40.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	40.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK
	1-4	5-8	9-12	13-16	17-20	21-24	LOAD
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.7	0.7	0.3	0.3	1509000
JUNE	0.3	0.3	0.7	0.7	0.3	0.3	1582000
JULY	0.3	0.3	0.7	0.7	0.3	0.3	1582000
AUGUST	0.3	0.3	0.7	0.7	0.3	0.3	1582000
SEPTEMBER	0.3	0.3	0.7	0.7	0.3	0.3	1582000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.8	1.8	1.7	1.6	1.6	1.7	31
JUNE	1.5	1.5	1.3	1.3	1.3	1.4	30
JULY	1.3	1.3	1.1	1.1	1.1	1.2	31
AUGUST	1.5	1.4	1.3	1.2	1.3	1.4	31
SEPTEMBER	1.5	1.5	1.4	1.4	1.4	1.5	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

	% DESIGN LOAD						DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	15.9	15.7	40.1	42.6	17.9	16.6	31
JUNE	20.6	20.5	52.7	54.6	23.0	21.4	30
JULY	23.3	23.3	62.4	66.7	27.2	24.8	31
AUGUST	20.7	20.7	54.6	56.6	23.4	21.6	31
SEPTEMBER	19.7	19.6	49.4	50.9	20.9	20.0	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

	SINGLE SPEED CONTROL (kWh)						TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	110	109	279	296	124	115	
JUNE	139	138	354	367	155	144	
JULY	161	162	433	463	189	172	
AUGUST	144	144	379	393	163	150	
SEPTEMBER	132	132	332	342	141	134	
OCTOBER	0	0	0	0	0	0	
TOTAL	686	685	1778	1861	771	716	6497

	TWO SPEED CONTROL (kWh)						TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	31	31	78	83	35	32	
JUNE	39	39	131	157	43	40	
JULY	45	45	270	329	53	48	
AUGUST	40	40	162	189	46	42	
SEPTEMBER	37	37	93	107	39	38	
OCTOBER	0	0	0	0	0	0	
TOTAL	192	192	733	864	216	200	2397

## **COST ESTIMATE ANALYSIS**

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5676EC5A

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991 DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91 ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	4072.
B. SIOH	\$	224.
C. DESIGN COST	\$	245.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	4087.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	4087.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	14.	\$ 56.	11.37	639.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		14.	\$ 56.		\$ 639.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)	\$	0.
(2) DISCOUNTED SAVING/COST (3A X 3A1)	11.65	\$ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33) \$ 211.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 56.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 639.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .16  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 72.78

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	6,497	--	22
ECO	--	1,527	--	5
Savings (Baseline-ECO)	0	4,970	0	17

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	17 MMBtu/Yr	X	\$4.0141 /MMBtu =	\$68 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu =	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$68 +</b>	<b>\$0</b>	<b>=</b>	<b>\$68 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$289 per year		
<b>Total:</b>	<b>\$0 -</b>	<b>\$289</b>	<b>=</b>	<b>(\$289) per year</b>	

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input (part 7). The control sequence is:

- 0-50% load, fan 1, half speed cycling.
- 50-100% load, fan 1 full speed cycling.

kWh per bin, for % design loads less than 50% load = (fan 1 power kW) \* 14% \* (%design load / 50) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 50% to 100% load = ( fan 1 power kW \* ((% design load)/ 100) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 5676	
DESIGN CONDITIONS	
- WBT (DB, DEG F)	77
- WATER FLOW (gpm)	525
- CNWR (DEG F)	95
- CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
- AIR FLOW (LBS/MIN)	2178.75
HEAT REJECTION CAPACITY (Btu/min)	
	43575
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	40.57
TOTAL ENTHALPY	60.57
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	32899
MOTOR DATA	
- FAN 1 POWER (kW)	5.6
- FAN 2 POWER (kW)	0
- FAN 3 POWER (kW)	0
- FAN 4 POWER (kW)	0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET-BULB AVERAGES (4 hour bins)						DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	77
MAY	57.1	56.6	61.2	63.9	63	59.4	77
JUNE	66.8	66.6	69.9	71	70.5	68.2	77
JULY	70.8	70.9	74.5	76	74.9	72.6	77
AUGUST	66.9	67	71	72	71	68.5	77
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	77
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	77

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	40.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	40.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	40.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	40.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	40.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	40.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	40.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK
	1-4	5-8	9-12	13-16	17-20	21-24	LOAD
							(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.7	0.7	0.3	0.3	1509000
JUNE	0.3	0.3	0.7	0.7	0.3	0.3	1582000
JULY	0.3	0.3	0.7	0.7	0.3	0.3	1582000
AUGUST	0.3	0.3	0.7	0.7	0.3	0.3	1582000
SEPTEMBER	0.3	0.3	0.7	0.7	0.3	0.3	1582000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.8	1.8	1.7	1.6	1.6	1.7	31
JUNE	1.5	1.5	1.3	1.3	1.3	1.4	30
JULY	1.3	1.3	1.1	1.1	1.1	1.2	31
AUGUST	1.5	1.4	1.3	1.2	1.3	1.4	31
SEPTEMBER	1.5	1.5	1.4	1.4	1.4	1.5	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

% DESIGN LOAD							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	15.9	15.7	40.1	42.6	17.9	16.6	31
JUNE	20.6	20.5	52.7	54.6	23.0	21.4	30
JULY	23.3	23.3	62.4	66.7	27.2	24.8	31
AUGUST	20.7	20.7	54.6	56.6	23.4	21.6	31
SEPTEMBER	19.7	19.6	49.4	50.9	20.9	20.0	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

SINGLE SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	110	109	279	296	124	115	
JUNE	139	138	354	367	155	144	
JULY	161	162	433	463	189	172	
AUGUST	144	144	379	393	163	150	
SEPTEMBER	132	132	332	342	141	134	
OCTOBER	0	0	0	0	0	0	
TOTAL	686	685	1778	1861	771	716	6497

TWO SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	31	31	78	83	35	32	
JUNE	39	39	131	157	43	40	
JULY	45	45	270	329	53	48	
AUGUST	40	40	162	189	46	42	
SEPTEMBER	37	37	93	107	39	38	
OCTOBER	0	0	0	0	0	0	
TOTAL	192	192	733	864	216	200	2397

	VARIABLE SPEED COOLING TOWER CYCLING (kWh)						TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	3	3	56	67	5	4	
JUNE	7	7	123	137	10	8	
JULY	11	11	211	257	17	13	
AUGUST	8	8	142	157	11	9	
SEPTEMBER	6	6	101	111	8	7	
OCTOBER	0	0	0	0	0	0	
TOTAL	36	36	633	730	52	41	1527

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5676EC5B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$ 4811.
B. SIOH	\$ 265.
C. DESIGN COST	\$ 289.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$ 4829.
E. SALVAGE VALUE COST	-\$ 0.
F. TOTAL INVESTMENT (1D-1E)	\$ 4829.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	17.	\$ 68.	11.37	774.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		17.	\$ 68.		\$ 774.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$ -289.
(1) DISCOUNT FACTOR (TABLE A)	11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$ -3367.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$ -3367.
D. PROJECT NON ENERGY QUALIFICATION TEST	
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$ 255.
A IF 3D1 IS = OR > 3C GO TO ITEM 4	
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=	_____
C IF 3D1B IS = > 1 GO TO ITEM 4	
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY	

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -221.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -2593.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.54  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -21.86

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.  
 It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	4	24,287	0	83

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	83 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$333 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$333</b>	<b>+</b>	<b>\$0</b>	<b>=</b>	<b>\$333 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	4 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$86 per year
Maintenance:	=	(-)			\$0 per year
<b>Total:</b>	<b>\$86</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$86 per year</b>

[ECO-SHT.WK3]

## HIGH EFFICIENCY MOTOR REPLACEMENT

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR	
730	CWP-1	150.0	179.0	147.0	0.87	460	90.19%	95.00%	5.73	2641	15120	\$330	
	CWP-2	150.0	179.0	148.0	0.91	460	86.22%	95.00%	11.50	1873	21539	\$542	
	CNWP-1	50.0	118.0	107.0	0.98	230	80.97%	93.00%	6.67	2641	17629	\$385	
	CNWP-2	50.0	118.0	107.0	0.99	230	80.15%	93.00%	7.27	468	3405	\$203	
	CNWP-3	NI	NI	NI									
	CTM-1	30.0	71.4	70.7	0.93	230	84.60%	92.40%	2.61	702	1834	\$81	
	CTM-2	30.0	71.4	71.0	0.87	230	90.44%	92.40%	0.58	702	405	\$18	
	HWP-1	50.0	125.0	117.5	0.87	230	86.10%	93.00%	3.51	3624	12722	\$250	
	HWP-2	50.0	125.0	118.0	0.87	230	86.10%	93.00%	3.53	3624	12776	\$251	
	DEMAND CREDIT			\$888	MMBtu		292	TOTAL		41		85430	\$2,058
914	CWP-1	40.0	48.0	41.3	0.87	460	89.69%	93.00%	1.14	3672	4178	\$82	
	CNWP-1	15.0	19.0	14.4	0.82	460	90.15%	90.20%	0.01	3672	23	\$0	
	CTM-1	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42	
	CTM-2	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42	
	HWP-1	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33	
	HWP-2	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34	
	DEMAND CREDIT			\$111	MMBtu		30	TOTAL		5		8932	\$233
	2812	CWP-1	20.0	27.0	23.0	0.77	460	90.07%	91.00%	0.16	3672	586	\$11
CNWP-1		25.0	31.5	26.5	0.82	460	91.18%	91.70%	0.11	3672	394	\$8	
CTM-1		15.0	18.6	18.6	0.87	460	86.79%	90.20%	0.56	1167	655	\$21	
HWP-1		7.5	21.6	18.5	0.87	230	74.74%	88.50%	1.33	5163	6888	\$123	
HWP-2		7.5	21.6	19.0	0.87	230	74.74%	88.50%	1.37	3672	5031	\$98	
DEMAND CREDIT			\$76	MMBtu		46	TOTAL		4		13554	\$261	
3442	CWP-1	60.0	73.0	63.0	0.84	460	91.62%	94.50%	1.40	3672	5158	\$10	
	CWP-2	60.0	73.0	63.4	0.84	460	91.62%	94.50%	1.41	3672	5191	\$10	
	CNWP-1	40.0	52.0	41.0	0.78	460	92.34%	93.00%	0.20	3672	721	\$14	
	CNWP-2	40.0	52.0	35.8	0.78	460	92.34%	93.00%	0.17	3672	629	\$12	
	CTM-1	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9	
	CTM-2	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9	
	CTM-3	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9	
	CTM-4	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9	
	DEMAND CREDIT			\$90	MMBtu		44	TOTAL		4		12880	\$266
	4701	CWP-1	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
CWP-2		50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6	
CNWP-1		30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45	
CNWP-2		30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45	
CTM-1		20.0	24.6	18.2	0.87	460	87.50%	91.00%	0.55	650	361	\$17	
CTM-2		15.0	19.2	16.5	0.87	440	87.90%	90.20%	0.32	650	206	\$10	
DEMAND CREDIT			\$65	MMBtu		16	TOTAL		3		4605	\$128	
5676	HCP-1	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150	
	HCP-2	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150	
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116	
	CTM-1	7.5	10.5	9	0.79	460	84.66%	88.50%	0.29	1160	337	\$11	
DEMAND CREDIT			\$94	MMBtu		83	TOTAL		4		24287	\$427	
5678	HCP-1	2.0	6.5	5.9	0.83	208	76.76%	84.00%	0.20	7296	1445	\$24	
	HCP-2	2.0	6.5	5.7	0.83	208	76.76%	84.00%	0.19	7296	1396	\$23	
	HCP-3	1.5	4.8	4.5	0.83	230	70.51%	84.00%	0.34	7296	2474	\$41	
	HCP-4	2.0	6.3	5.8	0.83	230	71.62%	84.00%	0.39	7296	2878	\$48	
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116	
	CTM-1	7.5	11	9.6	0.75	460	85.12%	88.50%	0.26	1139	293	\$10	
DEMAND CREDIT			\$64	MMBtu		49	TOTAL		3		14412	\$262	

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LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5676EC6

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	4547.
B. SIOH	\$	250.
C. DESIGN COST	\$	273.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	4563.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	4563.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	83.	\$ 333.	11.37	3784.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		83.	\$ 333.		\$ 3784.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	86.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	1002.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	1002.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1249.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 419.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 4785.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.05  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 10.90

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-7  
**SYSTEM MODIFICATION:** INSTALL INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-7, install instrumentation to facilitate efficient operation of boiler plant. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	0	13	13

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	13 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$38 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$38</b>	<b>=</b>	<b>\$38 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$320 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$320</b>	<b>=</b>	<b>(\$320) per year</b>

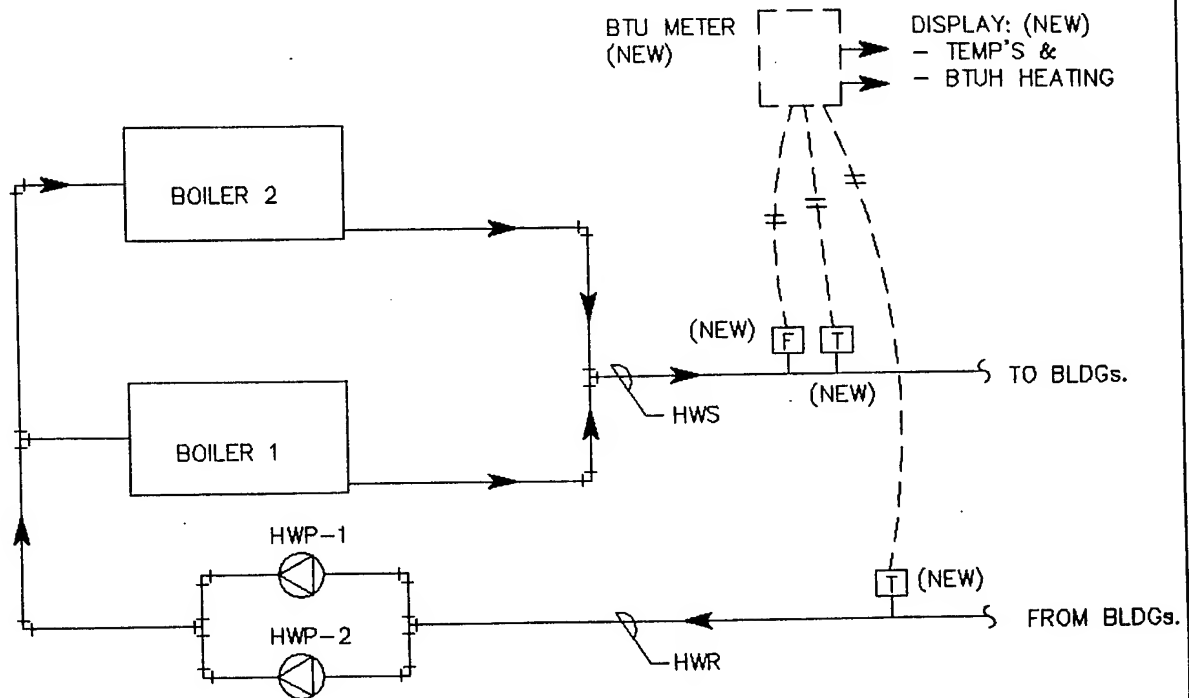
[ECO-SHT.WK3]

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (1%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS STANDBY SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0	51.62	\$150.74
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	54.82	\$160.09
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.55	\$159.27
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	\$159.27
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0		
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0	160.99	\$470.10
					TOTAL	9.41	0.0941	0		
6003	1	STEAM-12	KEWANE	L39-350-605	11.72	9.12	0.0912	0		
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0		
	3	STEAM-12	KEWANE	L36-350-605	11.72	9.37	0.0937	720	67.45	\$196.96
					TOTAL	2.11	0.0211	720	67.45	\$196.96
730	1	STEAM-12	KEWANE	CAT #7L286-KX	7.75	6.16	0.0616	0	44.34	\$129.47
	2	STEAM-12	KEWANE	CAT #7L286-KX	7.75	6.16	0.0616	720	44.51	\$129.96
	3	STEAM-12	KEWANE	CAT #7L286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANE	CAT #7L280-KG-06	2.66	2.11	0.0211	0	88.84	\$259.43
					TOTAL	1.40	0.0140	0		
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3562	1.80	2.77	0.0277	0		
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.62	\$60.21
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.62	\$60.21
					TOTAL	1.80	0.0180	720	12.93	\$37.76
5676	1	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
					TOTAL	1.50	0.0150	720	10.79	\$31.50
5678	1	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
					TOTAL	1.29	0.0129	720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.61	1.22	0.0122	0		
	2	HW	RAY-PAK	EA 200ITB	1.61	1.22	0.0122	0		
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0		
					TOTAL	8.43	0.0843	720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
					TOTAL	8.43	0.0843	720	60.73	\$177.33

[BOILERS WK3]

# ECO-7, INSTRUMENTATION FOR BOILER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[B-ECO-7.DWG]

[illegible]

DA FORM 1 APR 85

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B5676EC1

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER INSTRUMENTATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	5327.
B. SIOH	\$	293.
C. DESIGN COST	\$	320.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5346.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5346.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	13.	\$ 38.	12.48	471.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		13.	\$ 38.		\$ 471.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-320.
(1) DISCOUNT FACTOR (TABLE A)			
(2) DISCOUNTED SAVING/COST (3A X 3A1)	9.11	\$	-2915.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-2915.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)		\$	155.
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -282.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -2444.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.46  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -18.94

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-9  
**SYSTEM MODIFICATION:** REPLACE BOILER WITH HIGHER EFFICIENCY BOILER  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-9, renovate or replace existing boilers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	13,462	13,462
ECO	--	--	9,942	9,942
Savings (Baseline-ECO)	0	0	3,520	3,520

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 3520 MMBtu/Yr X \$2.92 /MMBtu = \$10,278 per year  
 Total Energy Cost Savings: \$0 + \$10,278 = \$10,278 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$0 per year  
 Total: \$0 - \$0 = \$0 per year

[ECO-SHT.WK3]

## CENTRAL PLANT 5676 BASELINE

## SYSTEM C1 NORMAL HEATING AND COOLING

\*\* TOTAL \*\*

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13463.
PEAK DAY GAS CONSUMP., 1000 CU FT	137.
ELECTRICAL CONSUMPTION, KWH	298696.
PEAK KW DEMAND (15 MIN BASIS)	165.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	298696.
ON-PEAK KW DEMAND (15 MIN BASIS)	165.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2057
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5676 BOILER ECO-3

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	9942.
PEAK DAY GAS CONSUMP., 1000 CU FT	100.
ELECTRICAL CONSUMPTION, KWH	298696.
PEAK KW DEMAND (15 MIN BASIS)	165.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	298696.
ON-PEAK KW DEMAND (15 MIN BASIS)	165.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	1541
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B5676EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER REPLACEMENT

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT
 

A. CONSTRUCTION COST	\$	99852.
B. SIOH	\$	5492.
C. DESIGN COST	\$	5992.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	100202.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	100202.
  
2. ENERGY SAVINGS (+) / COST (-)  
 ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS
 

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	3520.	\$ 10278.	17.52	180078.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		3520.	\$ 10278.		\$ 180078.
  
3. NON ENERGY SAVINGS(+) / COST(-)
 

A. ANNUAL RECURRING (+/-)	\$	-1792.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-20877.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-20877.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	59426.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		
  
4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 8486.
5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 159201.
6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.59  
 (IF < 1 PROJECT DOES NOT QUALIFY)
7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 11.81

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 10  
**SYSTEM MODIFICATION:** OXYGEN TRIM FOR BURNERS  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-10, install oxygen trim for burners.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	13,462	13,462
ECO	--	--	13,224	13,224
Savings (Baseline-ECO)	0	0	238	238

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 238 MMBtu/Yr X \$2.92 /MMBtu = \$695 per year  
**Total Energy Cost Savings: \$0 + \$695 = \$695 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$1,799 per year  
**Total: \$0 - \$1,799 = (\$1,799) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5676 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13463.
PEAK DAY GAS CONSUMP., 1000 CU FT	137.
ELECTRICAL CONSUMPTION, KWH	298696.
PEAK KW DEMAND (15 MIN BASIS)	165.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	298696.
ON-PEAK KW DEMAND (15 MIN BASIS)	165.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2057
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5676 BOILER ECO-4

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13224.
PEAK DAY GAS CONSUMP., 1000 CU FT	135.
ELECTRICAL CONSUMPTION, KWH	298696.
PEAK KW DEMAND (15 MIN BASIS)	165.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	298696.
ON-PEAK KW DEMAND (15 MIN BASIS)	165.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2030
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# SPECIFICATIONS - AIR-MIZER II SYSTEM

## SENSOR



**Nominal Dimensions:** 14 1/8" H x 10 1/4" W x 10" D (37.2 x 26 x 25.4 cm)

**Enclosure:** Weather resistant—S.S. case, nickel plated carbon steel base

**Weight:** 55 pounds (25 kg)

**Accuracy:**  $\pm 1\%$  of net excess oxygen

**Repeatability:**  $\pm 0.2\%$  of measured value

**Response:** 90% of full scale in less than 5 seconds

**Drift:** Less than 0.1% of sensor cell output per month

**Ambient Temperatures:**  $-5$  to  $+175^{\circ}\text{F}$  ( $-20.5$  to  $+79^{\circ}\text{C}$ )

**Sample Temperatures:** Up to  $1300^{\circ}\text{F}$  ( $704^{\circ}\text{C}$ ) with standard probe

**Sample Flow Rate:** 0.1 to 120 scfh (0.47 to 56.65 liters/minute)

**Air Aspirator Requirements:** 10 to 20 scfh (4.72 to 14.16 liters/min) at 15-100 psl (1.05 to 7.037 kg/cm<sup>2</sup>) (Aspirator air regulator furnished with sensor normally set at 2-7 psl; 0.14 - 0.49 kg/cm<sup>2</sup>)

**Calibration:** With analyzed oxygen in nitrogen sample. Calibration port provided.

## CONTROL UNIT

**Nominal Dimensions:** 12 1/8" H x 10 1/4" W x 9 1/4" D (32.1 x 27.6 x 23.2 cm)

**Enclosure:** Wall/panel mounted—meets the requirements for NEMA 4 areas

**Weight:** 22 pounds (10 kg)

**Temperature Control:** On-Off by microprocessor ( $\pm 1^{\circ}\text{C}$ )

**Linearization:** 256 segments from 20% to 0.2% O<sub>2</sub>, (218 from 10% to 0.2%), by microprocessor

**Controller Action:** On-Off—"On" time adjustable 2-20 seconds. "Off" time adjustable 2-60 seconds.

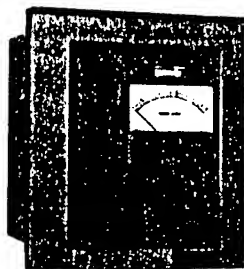
Deadband:  $\pm 0.25\%$  oxygen.

LED's indicate motor driving.

Will not allow decrease in air when O<sub>2</sub> is below 0.5% oxygen.

Air flow will increase to  $+15\%$  max. If O<sub>2</sub> level is above 12%.

**Setpoint:** 0 to 10% oxygen by either of: A. Two banks of 5 slide pots, (Dual Fuel) selectable by slide switch; proper pot or pots connected to processor by switch in actuator. B. Manual pot on panel A or B selected by Remote/Local switch on panel. Setpoint indicated by edge reading meter (0-10%)



**Manual Control:** Manual/Auto switch and increase—decrease push buttons (Spring return switch inside control unit can override all control actions in the event of processor failure).

**Ready Indicator:** On at temperature set point. Off below temperature set point. Flashes above temperature set point. O<sub>2</sub> Control in "manual" when below set point.

**Oxygen Scale:** 20.9 to 0.1% O<sub>2</sub>, Logarithmic

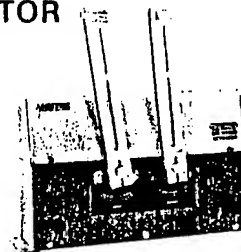
**Alarms:** High and Low O<sub>2</sub> adjustable 0.2 to 20%. RTD Failure (shuts down temperature control, and puts O<sub>2</sub> control in "manual").

**Increase Air Override:** Contact closure from optional combustibles or smoke detector alarm will cause increase in air signal on each control pulse regardless of O<sub>2</sub> vs. O<sub>2</sub> setpoint relationship. Once combustibles contact opens, normal control will resume. This maintains air flow at a level where maximum allowable combustibles or smoke is not exceeded.

**Ambient Temperature Limits:**  $32^{\circ}\text{F}$  to  $140^{\circ}\text{F}$  ( $0$  to  $+60^{\circ}\text{C}$ )

**Recorder Output:** 0-100 mv = 0-20% O<sub>2</sub> Linear (0-50 mv = 0-10%) Other current or voltages outputs optional

## ACTUATOR



**Overall Size:** 17 1/2" L x 4" W x 10 1/4" H (44.5 x 10.2 x 26 cm)

**Weight:** 16.5 pounds (7.5 kg)

**Angular Travel (Input Arm):**  $60^{\circ}$

**Linear Link Travel:** Adjustable 4" to 10" at 4" to 10" Radius (10.2 to 25.4 cm at 10.2 to 25.4 cm Radius)

**Linear Link Force:** 100 pounds at 4" Radius (45.5 kg at 10.2 cm Radius)

70 pounds at 6" Radius (31.8 kg at 15.2 cm Radius)

40 pounds at 10" Radius (18.2 kg at 25.4 cm Radius)

**Case:** Suitable for areas requiring NEMA 2 equipment (Drip proof indoor)

**Correction:**  $-15\%$  to  $+15\%$  (.85 to 1.15 gain) of normal air flow

**Speed:** 60 seconds from  $-15\%$  to  $+15\%$  correction (max.)

**Load Indication:** 9 position shorting switch tied to Input arm

**Brake:** Internal brake will hold load at any above rated force without "coasting"

**Ambient Temperature Limits:**  $0^{\circ}\text{F}$  to  $160^{\circ}\text{F}$  ( $-18$  to  $+71^{\circ}\text{C}$ )



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5676EC10

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER O2 TRIM CONTROL

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	23572.
B. SIOH	\$	1297.
C. DESIGN COST	\$	1415.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	23656.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	23656.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	238.	\$ 695.	12.48	8673.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		238.	\$ 695.		\$ 8673.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-1799.
(1) DISCOUNT FACTOR (TABLE A)	9.11		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	-16389.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-16389.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)		\$	2862.
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= _____			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -1104.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -7716.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -0.33  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -21.43

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5676  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 12  
**SYSTEM MODIFICATION:** STACK ECONOMIZERS  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-12, install stack economizer for boilers.  
 The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	13,462	13,462
ECO	--	--	12,744	12,744
Savings (Baseline-ECO)	0	0	718	718

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 718 MMBtu/Yr X \$2.92 /MMBtu = \$2,097 per year  
 Total Energy Cost Savings: \$0 + \$2,097 = \$2,097 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$0 per year  
 Total: \$0 - \$0 = \$0 per year

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

## CENTRAL PLANT 5676 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	13463.
PEAK DAY GAS CONSUMP., 1000 CU FT	137.
ELECTRICAL CONSUMPTION, KWH	298696.
PEAK KW DEMAND (15 MIN BASIS)	165.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	298696.
ON-PEAK KW DEMAND (15 MIN BASIS)	165.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2057
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

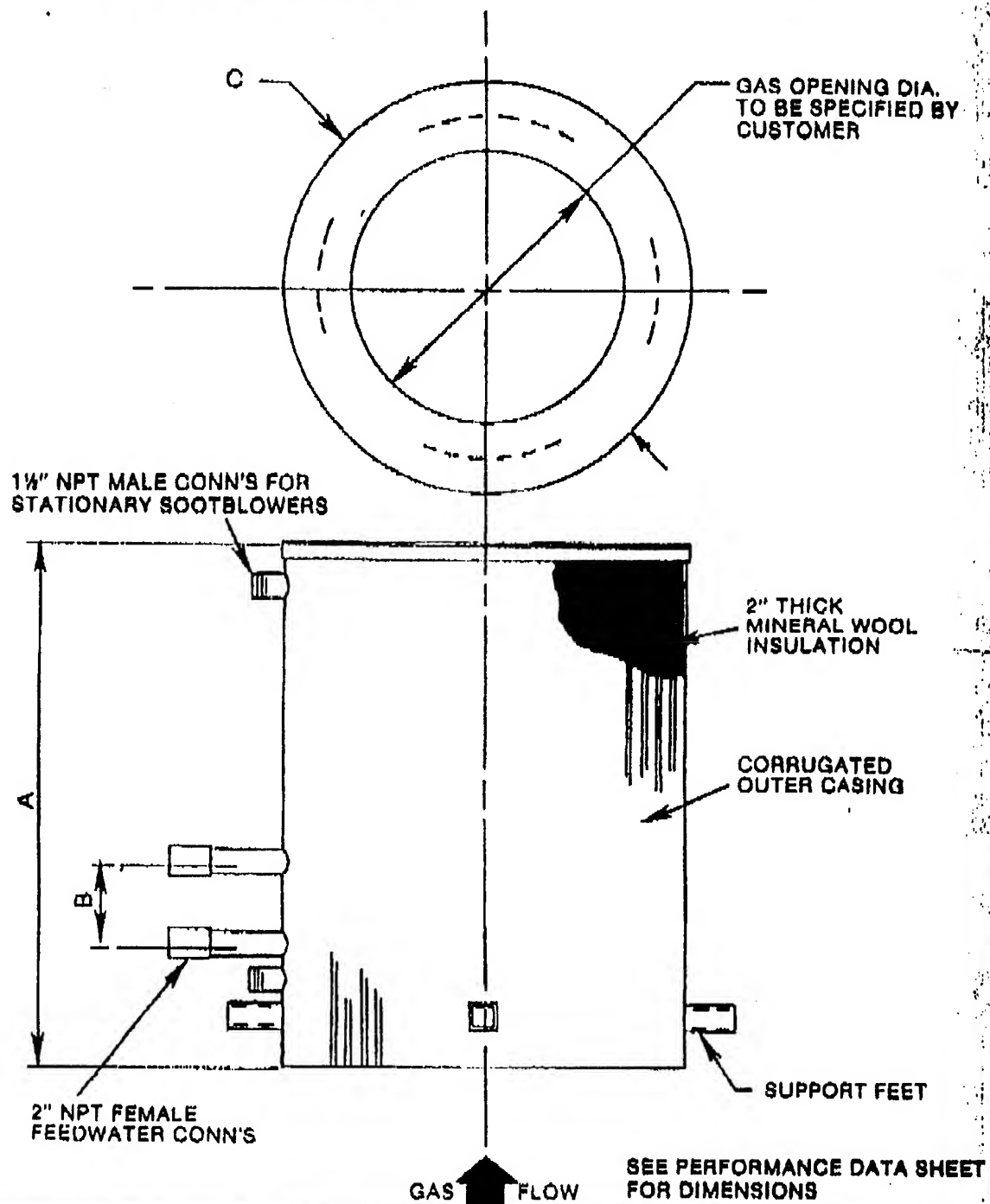
CENTRAL PLANT 5676 BOILER ECO-6

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	12744.
PEAK DAY GAS CONSUMP., 1000 CU FT	129.
ELECTRICAL CONSUMPTION, KWH	298696.
PEAK KW DEMAND (15 MIN BASIS)	165.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	298696.
ON-PEAK KW DEMAND (15 MIN BASIS)	165.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	1994
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# Kentube cylindrical ~~horizontal~~ fuel economizer



4160 South Elwood • Tulsa, Oklahoma 47107  
918/446-4551 • Telex: 49-2353

CRFE-V4

\*\*\*OFT\*\*\*

CUSTOMER

EMC Engineers

PROPOSAL 318-10350-0-0

RUN 00

KENTUBE

4150 S. ELWOOD

TULSA, OKLAHOMA

PRINTED 04/10/91

TIME 09 HRS 06 MINS

CUST. REFERENCE

CYLINDRICAL FUEL ECONOMIZER

MODEL 201140

OVERALL PERFORMANCE

COUNTER CURRENT FLOW

FLUID CIRCULATED IN TUBES IS WATER

HEAT EXCHANGED 552023. BTU/HR

U EXTERNAL 6.938 BTU/HR-SQFT-F

LMTD 160.3 DEG F

OVERALL CONSTRUCTION

VERTICAL GAS FLOW

DIMENSIONS

DIM A (HEIGHT) 7'-3/4"

DIM B (NOZ C-C) 0'-5 1/2"

DIM C (DIAMETER) 2'-9 3/4"

DRAWING NO V-4

SOOT BLOWERS ARE BUILT IN

NOZZLE SIZE 2.0 IN

SURFACE AREA 496. SQFT

LIQUID WEIGHT 175. LB

UNIT WEIGHT(DRY) 1768. LB

PERFORMANCE SPECIFICATIONS

TUBE SIDE GAS SIDE

↓

↑

	TUBE SIDE	GAS SIDE	
FLOW RATE	8620.	10307.	LB/HR
TEMP IN	180.0	500.0	DEG F
TEMP OUT	243.9	299.1	DEG F
PRES IN	180.0 PSIG	14.7	PSIA
PRES DROP	1.1 PSI	.77	IN WATER

CONSTRUCTION SPECIFICATIONS

TUBE SIDE

DESIGN PRESSURE	490.	PSI
TEST PRESSURE	735.	PSI
DESIGN TEMPERATURE	700.	DEG
TUBE OUTSIDE DIA	2.000	IN
MATERIAL	C/STL	
FIN THICKNESS	.040	IN
PITCH	4.00	FIN/IN
MATERIAL	C/STL	
INSULATION		
MATERIAL	MINERAL WOOL	
THICKNESS	2.0	IN



4150 S. Elwood  
Tulsa, Oklahoma 74107  
Phone: (918) 446-4361  
FAX: (918) 446-4360

# QUOTATION

T O	<b>EMC Engineers</b> 2750 South Wadsworth Blvd. Denver, CO 80227  Attention: Mr. Dennis Jones	QUOTATION DATE	YOUR REFERENCE		OUR REFERENCE
		04/10/91			318-10350-0-0
		SHIPPING ESTIMATE	TERMS		PAGE 1 OF 2
		8 Weeks*	Net 30 Days		
		SHIPPING DESTINATION	F.O.B. Kentube Shop**		

THANK YOU FOR YOUR INQUIRY. WE APPRECIATE THE OPPORTUNITY TO PROPOSE THE FOLLOWING:

ITEM	QUANTITY	DESCRIPTION	UNIT AMOUNT	AMOUNT
	8	<p><b>Kentube RETROMISER Fuel Economizer Cylindrical Model 201140, in accordance with the attached performance specifications.</b></p> <p style="text-align: center;"><u>DESIGN FEATURES</u></p> <p>Finned tube unit; 4 Fins per inch; Vertical gas flow; Counter-current flow Fuel type: NATURAL GAS.</p> <p>Estimated Shipping Weight - 1768. LBS.</p> <p>Pressure parts to Section I of the ASME Boiler &amp; Pressure Vessel Code.</p> <p>External 2" insulation with weatherproof, corrugated casing is included.</p> <p>Threaded drain and vent connections included.</p> <p>Kentube manually operated sootblower, integral with unit, included. Requires 85 psig to 250 psig supply pressure.</p>		\$ 39312.

## ENCLOSURES

cc: Ted D. Miller Associates

NOTE: All shipping estimates are based on "after receipt of order" and "after final print approvals" as required. Shipments can often be improved upon request. Please contact Kentube. Prices firm for 30 days and subject to change thereafter. No provision is made for Federal, State or Municipal taxes. All orders are subject to acceptance or rejection by the Credit Department of Kentube and to the Terms of Sale attached.

## YOUR REPRESENTATIVE IS:

Ted D. Miller Associates  
2140 South Ivanhoe  
Denver, CO 80222

## YOUR ORDER WILL RECEIVE OUR PROMPT ATTENTION

KENTUBE FABRICATED PRODUCTS

*Larry Wolfenbarger*  
Larry Wolfenbarger  
Product Sales Engineer



**Kentube**  
KENTUBE FABRICATED PRODUCTS

**FABRICATED PRODUCTS**

# QUOTATION

TO

KMC Engineers

/312-10350-0-0

PAGE 2 OF 2

ITEM	QUANTITY	DESCRIPTION	UNIT AMOUNT	AMOUNT
<p align="center"><b>SUGGESTED ACCESSORIES</b> (Quantities below are for each unit)</p>				
1		Bolted access manway in casing, approximately 16" Square, carbon steel construction.	\$ 100.	\$ 100.
1		1/2" Threaded connection for safety relief valve on header.	\$ 100.	\$ 100.
1		1/2" Threaded safety relief valve, Kunkle series 927.	\$ 555.	\$ 555.
<p>-- All prepaid and bill shipments will be at the billable freight amount plus a service charge of 10%. A service charge is not required for collect shipments or third party billing.</p>				
<p align="center">***** * KENTUBE is a member of the * * AMERICAN BOILER MANUFACTURERS ASSOCIATION * *****</p>				



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5676EC11

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY STUDY ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ECONOMIZER AIR PREHEAT

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$ 29286.
B. SIOH	\$ 1611.
C. DESIGN COST	\$ 1758.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$ 29390.
E. SALVAGE VALUE COST	-\$ 0.
F. TOTAL INVESTMENT (1D-1E)	\$ 29390.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	718.	\$ 2097.	17.52	36732.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		718.	\$ 2097.		\$ 36732.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      11.65

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 12121.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F= \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 2097.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 36732.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.25

(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 14.02

**CENTRAL PLANT 5678**

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	142	0	0	0

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$0</b>	<b>+</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	142 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)	\$3,045		per year
Maintenance:	=	(-)	\$0		per year
<b>Total:</b>	<b>\$3,045</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$3,045 per year</b>

# A new application of an old idea that can cut air conditioning energy costs in half.

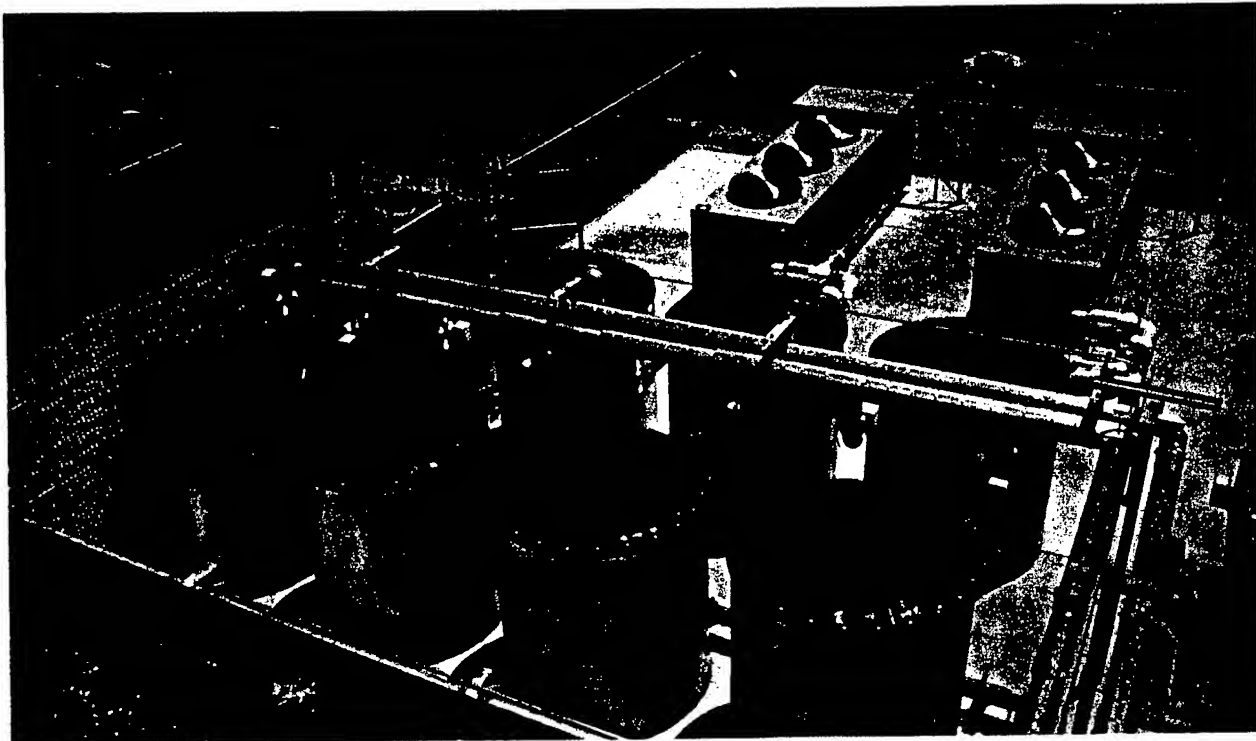
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

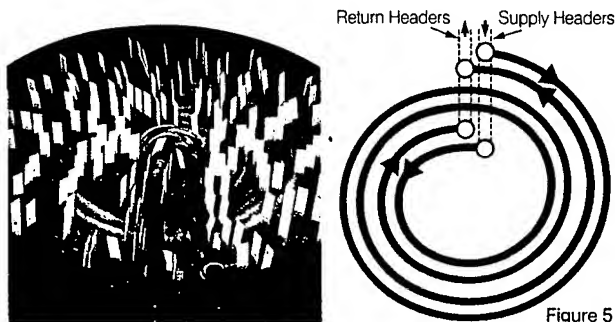
Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes - 90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.



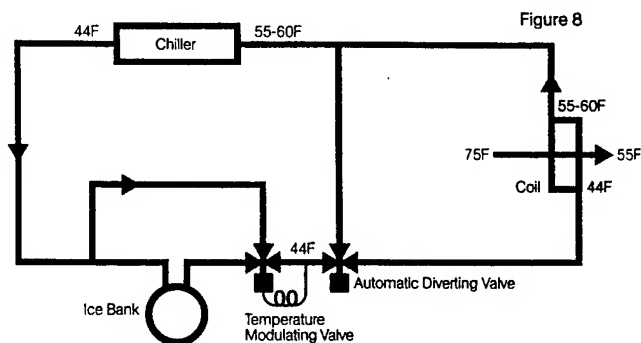
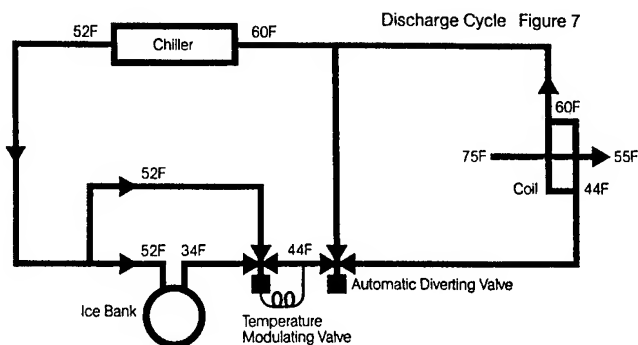
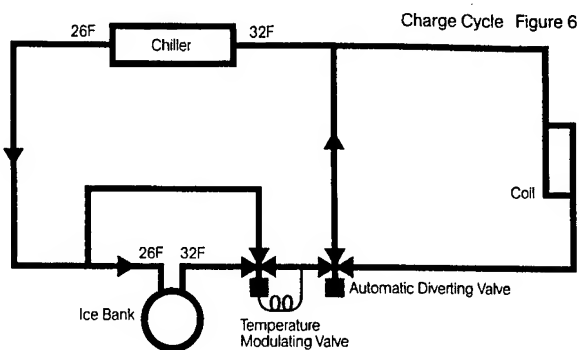
Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.



The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's Dowtherm® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5678EC4

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM

ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	48000.
B. SIOH	\$	2640.
C. DESIGN COST	\$	2880.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	48168.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	48168.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	3045.
(1) DISCOUNT FACTOR (TABLE A)	11.65		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	35474.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	35474.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	0.	
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=		.00	
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 3045.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 35474.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .74  
 (IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 15.82

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(A)  
**SYSTEM MODIFICATION:** TWO SPEED FANS FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	6,153	--	21
ECO	--	2,280	--	8
Savings (Baseline-ECO)	0	3,873	0	13

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	13 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$53 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$53</b>	<b>+</b>	<b>\$0</b>	<b>=</b>	<b>\$53 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$0 per year
Maintenance:	=	(-)			\$0 per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input (part 7). The control sequence is:

- 0-50% load, fan 1, half speed cycling.
- 50-100% load, fan 1 full speed cycling.

kWh per bin, for % design loads less than 50% load = (fan 1 power kW) \* 14% \* (%design load / 50) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 50% to 100% load = ( fan 1 power kW \* ((% design load)/ 100) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

<b>CENTRAL PLANT</b>		<b>5678</b>
<b>DESIGN CONDITIONS</b>		
– WBT (DB, DEG F)		77
– WATER FLOW (gpm)		570
– CNWR (DEG F)		95
– CNWS (DEG F)		85
<b>ASSUMPTION LIQUID TO GAS RATIO</b>		<b>2</b>
– AIR FLOW (LBS/MIN)		2365.5
<b>HEAT REJECTION CAPACITY (Btu/min)</b>		<b>47310</b>
DELTA ENTHALPY (Btu/lb)		20
DESIGN ENTHALPY (Btu/lb)		40.57
TOTAL ENTHALPY		60.57
EXIT AIR WB (LOOK UP)		93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)		15.1
100% DESIGN CFM @ WB		35719
<b>MOTOR DATA</b>		
– FAN 1 POWER (kW)		5.4
– FAN 2 POWER (kW)		0
– FAN 3 POWER (kW)		0
– FAN 4 POWER (kW)		0

**ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA**

	WET – BULB AVERAGES (4 hour bins)						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	77
MAY	57.1	56.6	61.2	63.9	63	59.4	77
JUNE	66.8	66.6	69.9	71	70.5	68.2	77
JULY	70.8	70.9	74.5	76	74.9	72.6	77
AUGUST	66.9	67	71	72	71	68.5	77
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	77
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	77

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	40.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	40.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	40.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	40.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	40.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	40.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	40.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK
	1-4	5-8	9-12	13-16	17-20	21-24	LOAD
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.7	0.7	0.3	0.3	1739000
JUNE	0.3	0.3	0.7	0.7	0.3	0.3	2056000
JULY	0.3	0.3	0.7	0.7	0.3	0.3	2056000
AUGUST	0.3	0.3	0.7	0.7	0.3	0.3	2056000
SEPTEMBER	0.3	0.3	0.7	0.7	0.3	0.3	2056000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.8	1.8	1.7	1.6	1.6	1.7	31
JUNE	1.5	1.5	1.3	1.3	1.3	1.4	30
JULY	1.3	1.3	1.1	1.1	1.1	1.2	31
AUGUST	1.5	1.4	1.3	1.2	1.3	1.4	31
SEPTEMBER	1.5	1.5	1.4	1.4	1.4	1.5	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

% DESIGN LOAD							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	
MAY	14.1	14.0	35.6	37.8	15.9	14.7	31
JUNE	20.6	20.5	52.7	54.6	23.0	21.4	30
JULY	23.3	23.3	62.4	66.7	27.2	24.8	31
AUGUST	20.7	20.7	54.6	56.6	23.4	21.6	31
SEPTEMBER	19.7	19.6	49.4	50.9	20.9	20.0	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

SINGLE SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	94	93	238	253	106	98	
JUNE	134	133	342	354	149	139	
JULY	156	156	418	446	182	166	
AUGUST	138	139	366	379	157	145	
SEPTEMBER	128	127	320	330	136	129	
OCTOBER	0	0	0	0	0	0	
TOTAL	650	648	1684	1763	730	678	6153

TWO SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	26	26	67	71	30	28	
JUNE	37	37	126	151	42	39	
JULY	44	44	260	317	51	46	
AUGUST	39	39	156	182	44	41	
SEPTEMBER	36	36	90	103	38	36	
OCTOBER	0	0	0	0	0	0	
TOTAL	182	182	698	824	204	190	2280

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5678EC5A

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	4072.
B. SIOH	\$	224.
C. DESIGN COST	\$	245.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	4087.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	4087.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	13.	\$ 53.	11.37	603.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		13.	\$ 53.		\$ 603.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	0.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	0.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	0.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	199.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 53.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 603.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .15  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 77.02

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	6,153	--	21
ECO	--	1,432	--	5
Savings (Baseline-ECO)	0	4,721	0	16

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	16 MMBtu/Yr	X	\$4.0141 /MMBtu =	\$65 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu =	\$0 per year
<b>Total Energy Cost Savings:</b>	<b>\$65 +</b>	<b>\$0</b>	<b>=</b>	<b>\$65 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$289 per year		
<b>Total:</b>	<b>\$0 -</b>	<b>\$289</b>	<b>=</b>	<b>(\$289) per year</b>	

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input (part 7). The control sequence is:

- 0-50% load, fan 1, half speed cycling.
- 50-100% load, fan 1 full speed cycling.

kWh per bin, for % design loads less than 50% load = (fan 1 power kW) \* 14% \* (% design load / 50) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 50% to 100% load = ( fan 1 power kW \* ((% design load)/ 100) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT	5678
DESIGN CONDITIONS	
– WBT (DB, DEG F)	77
– WATER FLOW (gpm)	570
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	2
– AIR FLOW (LBS/MIN)	2365.5
HEAT REJECTION CAPACITY (Btu/min)	47310
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	40.57
TOTAL ENTHALPY	60.57
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	35719
MOTOR DATA	
– FAN 1 POWER (kW)	5.4
– FAN 2 POWER (kW)	0
– FAN 3 POWER (kW)	0
– FAN 4 POWER (kW)	0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET-BULB AVERAGES (4 hour bins)						DESIGN WB
	1–4	5–8	9–12	13–16	17–20	21–24	
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	77
MAY	57.1	56.6	61.2	63.9	63	59.4	77
JUNE	66.8	66.6	69.9	71	70.5	68.2	77
JULY	70.8	70.9	74.5	76	74.9	72.6	77
AUGUST	66.9	67	71	72	71	68.5	77
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	77
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	77

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	40.57
MAY	24.53	24.21	27.28	29.23	28.57	26.06	40.57
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	40.57
JULY	34.77	34.86	38.14	39.57	38.52	36.37	40.57
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	40.57
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	40.57
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	40.57

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD
	1-4	5-8	9-12	13-16	17-20	21-24	(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.7	0.7	0.3	0.3	1739000
JUNE	0.3	0.3	0.7	0.7	0.3	0.3	2056000
JULY	0.3	0.3	0.7	0.7	0.3	0.3	2056000
AUGUST	0.3	0.3	0.7	0.7	0.3	0.3	2056000
SEPTEMBER	0.3	0.3	0.7	0.7	0.3	0.3	2056000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.8	1.8	1.7	1.6	1.6	1.7	31
JUNE	1.5	1.5	1.3	1.3	1.3	1.4	30
JULY	1.3	1.3	1.1	1.1	1.1	1.2	31
AUGUST	1.5	1.4	1.3	1.2	1.3	1.4	31
SEPTEMBER	1.5	1.5	1.4	1.4	1.4	1.5	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

	% DESIGN LOAD						DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	
MAY	14.1	14.0	35.6	37.8	15.9	14.7	31
JUNE	20.6	20.5	52.7	54.6	23.0	21.4	30
JULY	23.3	23.3	62.4	66.7	27.2	24.8	31
AUGUST	20.7	20.7	54.6	56.6	23.4	21.6	31
SEPTEMBER	19.7	19.6	49.4	50.9	20.9	20.0	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

	SINGLE SPEED CONTROL (kWh)						TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	94	93	238	253	106	98	
JUNE	134	133	342	354	149	139	
JULY	156	156	418	446	182	166	
AUGUST	138	139	366	379	157	145	
SEPTEMBER	128	127	320	330	136	129	
OCTOBER	0	0	0	0	0	0	
TOTAL	650	648	1684	1763	730	678	6153

	TWO SPEED CONTROL (kWh)						TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	26	26	67	71	30	28	
JUNE	37	37	126	151	42	39	
JULY	44	44	260	317	51	46	
AUGUST	39	39	156	182	44	41	
SEPTEMBER	36	36	90	103	38	36	
OCTOBER	0	0	0	0	0	0	
TOTAL	182	182	698	824	204	190	2280

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	2	2	38	45	3	3	
JUNE	7	7	119	132	10	8	
JULY	11	11	204	248	17	13	
AUGUST	7	7	137	152	11	8	
SEPTEMBER	6	6	98	107	7	6	
OCTOBER	0	0	0	0	0	0	
TOTAL	34	33	594	684	48	38	1432



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 5678EC5B  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER  
 ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	4811.
B. SIOH	\$	265.
C. DESIGN COST	\$	289.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	4829.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	4829.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	16.	\$ 65.	11.37	735.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		16.	\$ 65.		\$ 735.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-289.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-3367.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-3367.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	243.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -224.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -2632.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= - .55  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -21.52

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.  
 It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	3	14,412	0	49

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	49 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$197 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$197 +</b>	<b>\$0</b>	<b>=</b>	<b>\$197 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	3 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$64 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$64</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$64 per year</b>

[ECO-SHT.WK3]

## HIGH EFFICIENCY MOTOR REPLACEMENT

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR
730	CWP-1	150.0	179.0	147.0	0.87	460	90.19%	95.00%	5.73	2641	15120	\$330
	CWP-2	150.0	179.0	148.0	0.91	460	86.22%	95.00%	11.50	1873	21539	\$542
	CNWP-1	50.0	118.0	107.0	0.98	230	80.97%	93.00%	6.67	2641	17629	\$385
	CNWP-2	50.0	118.0	107.0	0.99	230	80.15%	93.00%	7.27	468	3405	\$203
	CNWP-3	NI	NI	NI								
	CTM-1	30.0	71.4	70.7	0.93	230	84.60%	92.40%	2.61	702	1834	\$81
	CTM-2	30.0	71.4	71.0	0.87	230	90.44%	92.40%	0.58	702	405	\$18
	HWP-1	50.0	125.0	117.5	0.87	230	86.10%	93.00%	3.51	3624	12722	\$250
	HWP-2	50.0	125.0	118.0	0.87	230	86.10%	93.00%	3.53	3624	12776	\$251
DEMAND CREDIT				\$888	MMBtu	292		TOTAL	41		85430	\$2,058
914	CWP-1	40.0	48.0	41.3	0.87	460	89.69%	93.00%	1.14	3672	4178	\$82
	CNWP-1	15.0	19.0	14.4	0.82	460	90.15%	90.20%	0.01	3672	23	\$0
	CTM-1	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	CTM-2	10.0	15.0	12.0	0.82	460	76.12%	89.50%	1.54	416	640	\$42
	HWP-1	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33
	HWP-2	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34
DEMAND CREDIT				\$111	MMBtu	30		TOTAL	5		8932	\$233
2812	CWP-1	20.0	27.0	23.0	0.77	460	90.07%	91.00%	0.16	3672	586	\$11
	CNWP-1	25.0	31.5	26.5	0.82	460	91.18%	91.70%	0.11	3672	394	\$8
	CTM-1	15.0	18.6	18.6	0.87	460	86.79%	90.20%	0.56	1167	655	\$21
	HWP-1	7.5	21.6	18.5	0.87	230	74.74%	88.50%	1.33	5163	6888	\$123
	HWP-2	7.5	21.6	19.0	0.87	230	74.74%	88.50%	1.37	3672	5031	\$98
DEMAND CREDIT				\$76	MMBtu	46		TOTAL	4		13554	\$261
3442	CWP-1	60.0	73.0	63.0	0.84	460	91.62%	94.50%	1.40	3672	5158	\$101
	CWP-2	60.0	73.0	63.4	0.84	460	91.62%	94.50%	1.41	3672	5191	\$101
	CNWP-1	40.0	52.0	41.0	0.78	460	92.34%	93.00%	0.20	3672	721	\$14
	CNWP-2	40.0	52.0	35.8	0.78	460	92.34%	93.00%	0.17	3672	629	\$12
	CTM-1	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-2	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-3	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
	CTM-4	15.0	18.3	14.6	0.87	460	88.21%	90.20%	0.25	1169	295	\$9
DEMAND CREDIT				\$90	MMBtu	44		TOTAL	4		12880	\$266
4701	CWP-1	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CWP-2	50.0	60.7	51	0.87	440	92.68%	93.00%	0.13	1873	235	\$6
	CNWP-1	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CNWP-2	30.0	38	33	0.87	440	88.83%	92.40%	0.95	1873	1784	\$45
	CTM-1	20.0	24.6	18.2	0.87	460	87.50%	91.00%	0.55	650	361	\$17
	CTM-2	15.0	19.2	16.5	0.87	440	87.90%	90.20%	0.32	650	206	\$10
DEMAND CREDIT				\$65	MMBtu	16		TOTAL	3		4605	\$128
5676	HCP-1	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	HCP-2	10.0	13.5	13	0.87	460	79.72%	89.50%	1.24	7296	9012	\$150
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	10.5	9	0.79	460	84.66%	88.50%	0.29	1160	337	\$11
DEMAND CREDIT				\$94	MMBtu	83		TOTAL	4		24287	\$427
5678	HCP-1	2.0	6.5	5.9	0.83	208	76.76%	84.00%	0.20	7296	1445	\$24
	HCP-2	2.0	6.5	5.7	0.83	208	76.76%	84.00%	0.19	7296	1396	\$23
	HCP-3	1.5	4.8	4.5	0.83	230	70.51%	84.00%	0.34	7296	2474	\$41
	HCP-4	2.0	6.3	5.8	0.83	230	71.62%	84.00%	0.39	7296	2878	\$48
	CNWP-1	7.5	11	10	0.87	460	73.38%	88.50%	1.61	3672	5927	\$116
	CTM-1	7.5	11	9.6	0.75	460	85.12%	88.50%	0.26	1139	293	\$10
DEMAND CREDIT				\$64	MMBtu	49		TOTAL	3		14412	\$262



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 5678EC6  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR  
 ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	4570.
B. SIOH	\$	252.
C. DESIGN COST	\$	275.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	4587.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	4587.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	49.	\$ 197.	11.37	2245.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		49.	\$ 197.		\$ 2245.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	64.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	746.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	746.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	741.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		.65
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 261.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 2991.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .65  
 (IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 17.54

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-7  
**SYSTEM MODIFICATION:** INSTALL INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-7, install instrumentation to facilitate efficient operation of boiler plant. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	0	11	11

**NOTE:** The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	11 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$32 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$32</b>	<b>=</b>	<b>\$32 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$0 per year
Maintenance:	=	(-)			\$320 per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$320</b>	<b>=</b>	<b>(\$320) per year</b>

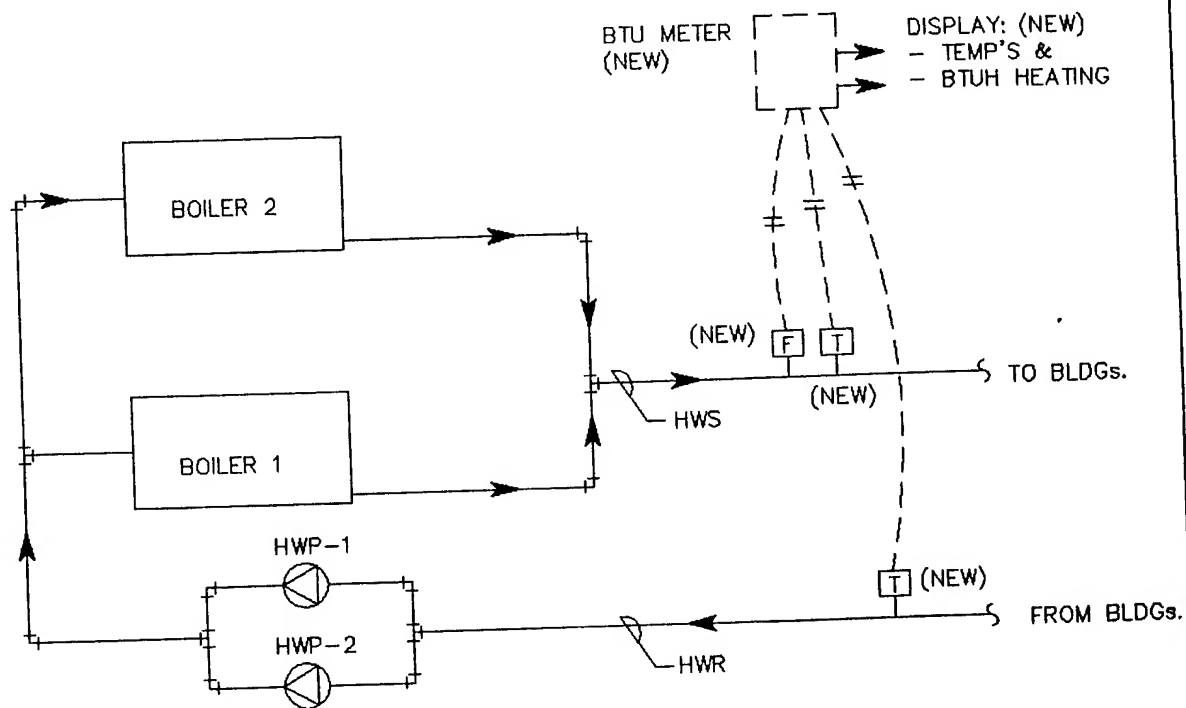
[ECO-SHT.WK3]

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (1%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS STANDBY SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0		
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	51.62	\$150.74
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.82	\$160.09
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	\$159.27
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0		
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0		
					TOTAL			2160	160.99	\$470.10
6003	1	STEAM-12	KEWANEE	L39-350-605	11.72	9.41	0.0941	0		
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0		
	3	STEAM-12	KEWANEE	L36-350-605	11.72	9.37	0.0937	720	67.45	\$196.96
					TOTAL			720	67.45	\$196.96
730	1	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	0		
	2	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	720	44.34	\$129.47
	3	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANEE	CAT#7L280-KG-06	2.66	2.11	0.0211	0		
					TOTAL			1440	88.84	\$259.43
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3562	1.80	1.40	0.0140	0		
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.77	0.0277	0		
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.62	\$60.21
					TOTAL			720	20.62	\$60.21
5676	1	HW	AMERICAN STANDARD	PF 515	2.44	1.80	0.0180	720	12.93	\$37.76
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
					TOTAL			720	12.93	\$37.76
5678	1	HW	BRUNHAM	PF 514	2.27	1.50	0.0150	720	10.79	\$31.50
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
					TOTAL			720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.61	1.29	0.0129	0		
	2	HW	RAY-PAK	EA 200ITB	1.61	1.22	0.0122	0		
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0		
					TOTAL			720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	0		
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0		
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
					TOTAL			720	60.73	\$177.33

[BOILERS.WK3]

# ECO-7, INSTRUMENTATION FOR BOILER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[B-ECO-7.DWG]

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B5678E12

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER INSTRUMENTATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	5327.
B. SIOH	\$	293.
C. DESIGN COST	\$	320.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5346.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5346.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	11.	\$ 32.	12.48	393.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		11.	\$ 32.		\$ 393.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -2915.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -2915.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 130.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F= \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -288.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -2522.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.47

(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -18.53

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-8  
**SYSTEM MODIFICATION:** BOILER OPTIMIZATION, CONTROL & INSTRUMENTATION  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-8, install instrumentation connected to EMCS for boiler optimization. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	16,330	16,330
ECO	--	--	16,058	16,058
Savings (Baseline-ECO)	0	0	272	272

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 272 MMBtu/Yr X \$2.92 /MMBtu = \$794 per year  
**Total Energy Cost Savings: \$0 + \$794 = \$794 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$1,632 per year  
**Total: \$0 - \$1,632 = (\$1,632) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

## CENTRAL PLANT 5678 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	16330.
PEAK DAY GAS CONSUMP., 1000 CU FT	136.
ELECTRICAL CONSUMPTION, KWH	233241.
PEAK KW DEMAND (15 MIN BASIS)	106.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	233241.
ON-PEAK KW DEMAND (15 MIN BASIS)	106.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2808
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5678 BOILER ECO-2

\*\* TOTAL \*\*

SYSTEM C1 NORMAL HEATING AND COOLING



FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	16057.
PEAK DAY GAS CONSUMP., 1000 CU FT	136.
ELECTRICAL CONSUMPTION, KWH	233241.
PEAK KW DEMAND (15 MIN BASIS)	106.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	233241.
ON-PEAK KW DEMAND (15 MIN BASIS)	106.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2767
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



\* - Points included on proposed EMCS.design, existing.  
All other points are new.

→ EMCS SIGNAL TRANSMITTED TO EMCS  
 ← EMCS SIGNAL TRANSMITTED FROM EMCS

[A]	ALARM CONTACT SIGNAL
[E]	ECONOMIZER CONTROL INTERFACE
[F]	FLOW INDICATION
[FL]	FLAME INDICATION
[H]	HUMIDITY INDICATION
[P]	PRESSURE INDICATION
[LV]	LEVEL INDICATION
[M]	METER
[O]	ON-OFF STATUS SIGNAL
[DP]	DIFFERENTIAL PRESSURE SWITCH
[R]	CONTROLLER RESET INTERFACE
[S]	START-STOP INTERFACE
[T]	TEMPERATURE INDICATION
[V]	VENTILATION/RECIRCULATION CONTROL
[PS]	POSITION
[O <sub>2</sub> ]	FLUE GAS ANALYSIS, OXYGEN
[Co]	FLUE GAS ANALYSIS, CARBON MONOXIDE

[FD]	FURNACE DRAFT DIFFERENTIAL PRESSURE
[DS]	HIGH-LOW DEMAND SIGNAL SELECTOR
(TC)	TEMPERATURE CONTROLLER
(PC)	PRESSURE CONTROLLER
[STR]	MOTOR STARTER
	SENSOR INSTALLED IN THERMOMETER WELL
	SENSOR INSTALLED IN DUCT OR PLENUM
CHW	CHILLED WATER
EA	EXHAUST AIR
SA	SUPPLY AIR
RA	RETURN AIR
OA	OUTSIDE AIR
MA	MIXED AIR
WB	WET BULB
DB	DRY BULB
OAD	OUTSIDE AIR DAMPER
RAD	RETURN AIR DAMPER
EAD	EXHAUST AIR DAMPER
MZD	MULTIZONE DAMPER
RH	RELATIVE HUMIDITY

Symbols and Abbreviations



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B5678E12

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991 DISCRETE PORTION NAME: BOILER OPTIMIZATION

ANALYSIS DATE: 04-12-91 ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	27203.
B. SIOH	\$	1497.
C. DESIGN COST	\$	1633.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	27300.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	27300.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	272.	\$ 794.	12.48	9912.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		272.	\$ 794.		\$ 9912.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-1632.
(1) DISCOUNT FACTOR (TABLE A)	9.11		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	-14868.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-14868.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	3271.	
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= _____			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -838.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -4955.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -.18  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -32.59

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-9  
**SYSTEM MODIFICATION:** REPLACE BOILER WITH HIGHER EFFICIENCY BOILER  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-9, renovate or replace existing boilers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	16,330	16,330
ECO	--	--	11,200	11,200
Savings (Baseline-ECO)	0	0	5,130	5,130

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 5130 MMBtu/Yr X \$2.92 /MMBtu = \$14,980 per year  
**Total Energy Cost Savings: \$0 + \$14,980 = \$14,980 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$3,000 per year  
**Total: \$0 - \$3,000 = (\$3,000) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

## CENTRAL PLANT 5678 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	16330.
PEAK DAY GAS CONSUMP., 1000 CU FT	136.
ELECTRICAL CONSUMPTION, KWH	233241.
PEAK KW DEMAND (15 MIN BASIS)	106.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	233241.
ON-PEAK KW DEMAND (15 MIN BASIS)	106.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2808
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5678 BOILER ECO-3

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	11199.
PEAK DAY GAS CONSUMP., 1000 CU FT	116.
ELECTRICAL CONSUMPTION, KWH	233241.
PEAK KW DEMAND (15 MIN BASIS)	106.
PURCHASED ELECTRIC POWER	233241.
ON-PEAK CONSUMPTION KWH	106.
ON-PEAK KW DEMAND (15 MIN BASIS)	0.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	3672
CHILLER 1	
BOILER OPERATING HOURS	3624
BOILER 1	1960
BOILER 2	
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

[illegible]

D-5678-41

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B5678EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER REPLACEMENT

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$ 99852.
B. SIOH	\$ 5492.
C. DESIGN COST	\$ 5992.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$ 100202.
E. SALVAGE VALUE COST	-\$ 0.
F. TOTAL INVESTMENT (1D-1E)	\$ 100202.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	5130.	\$ 14980.	17.52	262443.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		5130.	\$ 14980.		\$ 262443.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)	\$ -1792.
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$ -20877.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -20877.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33) \$ 86606.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 13188.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 241566.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 2.41  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 7.60

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 10  
**SYSTEM MODIFICATION:** OXYGEN TRIM FOR BURNERS  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-10, install oxygen trim for burners.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	16,330	16,330
ECO	--	--	14,793	14,793
Savings (Baseline-ECO)	0	0	1,537	1,537

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 1537 MMBtu/Yr X \$2.92 /MMBtu = \$4,488 per year  
 Total Energy Cost Savings: \$0 + \$4,488 = \$4,488 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$1,799 per year  
 Total: \$0 - \$1,799 = (\$1,799) per year

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

## CENTRAL PLANT 5678 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	16330.
PEAK DAY GAS CONSUMP., 1000 CU FT	136.
ELECTRICAL CONSUMPTION, KWH	233241.
PEAK KW DEMAND (15 MIN BASIS)	106.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	233241.
ON-PEAK KW DEMAND (15 MIN BASIS)	106.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2808
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5678 BOILER ECO-4

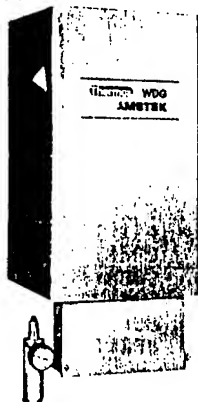
\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	14792.
PEAK DAY GAS CONSUMP., 1000 CU FT	136.
ELECTRICAL CONSUMPTION, KWH	233241.
PEAK KW DEMAND (15 MIN BASIS)	106.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	233241.
ON-PEAK KW DEMAND (15 MIN BASIS)	106.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2637
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# SPECIFICATIONS — AIR-MIZER II SYSTEM

## SENSOR



**Nominal Dimensions:** 14 1/4" H x 10 1/4" W x 10" D (37.2 x 26 x 25.4 cm)

**Enclosure:** Weather resistant—S.S. case, nickel plated carbon steel base

**Weight:** 55 pounds (25 kg)

**Accuracy:**  $\pm 1\%$  of net excess oxygen

**Repeatability:**  $\pm 0.2\%$  of measured value

**Response:** 90% of full scale in less than 5 seconds

**Drift:** Less than 0.1% of sensor cell output per month

**Ambient Temperatures:**  $-5$  to  $+175^{\circ}\text{F}$  ( $-20.5$  to  $+79^{\circ}\text{C}$ )

**Sample Temperatures:** Up to  $1300^{\circ}\text{F}$  ( $704^{\circ}\text{C}$ ) with standard probe

**Sample Flow Rate:** 0.1 to 120 scfh (0.47 to 56.65 liters/minute)

**Air Aspirator Requirements:** 10 to 20 scfh (4.72 to 14.16 liters/min) at 15-100 psi (1.05 to 7.037 kg/cm<sup>2</sup>) (Aspirator air regulator furnished with sensor normally set at 2-7 psi; 0.14 - 0.49 kg/cm<sup>2</sup>)

**Calibration:** With analyzed oxygen in nitrogen sample. Calibration port provided.

## CONTROL UNIT

**Nominal Dimensions:** 12 1/4" H x 10 1/4" W x 9 1/4" D (32.1 x 27.6 x 23.2 cm)

**Enclosure:** Wall/panel mounted—meets the requirements for NEMA 4 areas

**Weight:** 22 pounds (10 kg)

**Temperature Control:** On-Off by microprocessor ( $\pm 1^{\circ}\text{C}$ )

**Linearization:** 256 segments from 20% to 0.2% O<sub>2</sub>, (218 from 10% to 0.2%), by microprocessor

**Controller Action:** On-Off—"On" time adjustable 2-20 seconds. "Off" time adjustable 2-60 seconds.

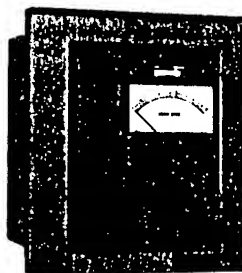
Deadband:  $\pm 0.25\%$  oxygen.

LED's Indicate motor driving.

Will not allow decrease in air when O<sub>2</sub> is below 0.5% oxygen.

Air flow will increase to  $+15\%$  max. If O<sub>2</sub> level is above 12%.

**Setpoint:** 0 to 10% oxygen by either of: A. Two banks of 5 slide pots, (Dual Fuel) selectable by slide switch; proper pot or pots connected to processor by switch in actuator. B. Manual pot on panel A or B selected by Remote/Local switch on panel. Setpoint Indicated by edge reading meter (0-10%)



**Manual Control:** Manual/Auto switch and increase—decrease push buttons (Spring return switch inside control unit can override all control actions in the event of processor failure).

**Ready Indicator:** On at temperature set point. Off below temperature set point. Flashes above temperature set point. O<sub>2</sub> Control in "manual" when below set point.

**Oxygen Scale:** 20.9 to 0.1% O<sub>2</sub> Logarithmic

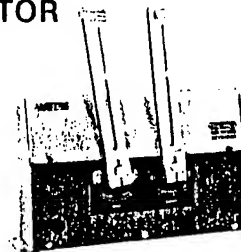
**Alarms:** High and Low O<sub>2</sub> adjustable 0.2 to 20%. RTD Failure (shuts down temperature control, and puts O<sub>2</sub> control in "manual").

**Increase Air Override:** Contact closure from optional combustibles or smoke detector alarm will cause Increase in air signal on each control pulse regardless of O<sub>2</sub> vs. O<sub>2</sub> setpoint relationship. Once combustibles contact opens, normal control will resume. This maintains air flow at a level where maximum allowable combustibles or smoke is not exceeded.

**Ambient Temperature Limits:**  $32^{\circ}\text{F}$  to  $140^{\circ}\text{F}$  ( $0$  to  $+60^{\circ}\text{C}$ )

**Recorder Output:** 0-100 mv = 0-20% O<sub>2</sub> Linear (0-50 mv = 0-10%) Other current or voltages outputs optional

## ACTUATOR



**Overall Size:** 17 1/2" L x 4" W x 10 1/4" H (44.5 x 10.2 x 26 cm)

**Weight:** 16.5 pounds (7.5 kg)

**Angular Travel (Input Arm):**  $60^{\circ}$

**Linear Link Travel:** Adjustable 4" to 10" at 4" to 10" Radius (10.2 to 25.4 cm at 10.2 to 25.4 cm Radius)

**Linear Link Force:** 100 pounds at 4" Radius (45.5 kg at 10.2 cm Radius)

70 pounds at 6" Radius (31.8 kg at 15.2 cm Radius)

40 pounds at 10" Radius (18.2 kg at 25.4 cm Radius)

**Case:** Suitable for areas requiring NEMA 2 equipment (Drip proof indoor)

**Correction:**  $-15\%$  to  $+15\%$  (.85 to 1.15 gain) of normal air flow

**Speed:** 60 seconds from  $-15\%$  to  $+15\%$  correction (max.)

**Load Indication:** 9 position shorting switch tied to Input arm

**Brake:** Internal brake will hold load at any above rated force without "coasting"

**Ambient Temperature Limits:**  $0^{\circ}\text{F}$  to  $160^{\circ}\text{F}$  ( $-18$  to  $+71^{\circ}\text{C}$ )



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5678EC10

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER O2 TRIM CONTROL

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	23572.
B. SIOH	\$	1297.
C. DESIGN COST	\$	1415.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	23656.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	23656.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	1537.	\$ 4488.	12.48	56011.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		1537.	\$ 4488.		\$ 56011.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-1799.
(1) DISCOUNT FACTOR (TABLE A)	9.11		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	-16389.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-16389.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	18484.	
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 2689.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 39622.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.67  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 8.80

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5678  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-12  
**SYSTEM MODIFICATION:** STACK ECONOMIZERS  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-12, install stack economizer for boilers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	16,330	16,330
ECO	--	--	16,134	16,134
Savings (Baseline-ECO)	0	0	196	196

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	196 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$572 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$572</b>	<b>=</b>	<b>\$572 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0 per year		
Maintenance:	= (-)		\$0 per year		
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5678 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	16330.
PEAK DAY GAS CONSUMP., 1000 CU FT	136.
ELECTRICAL CONSUMPTION, KWH	233241.
PEAK KW DEMAND (15 MIN BASIS)	106.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	233241.
ON-PEAK KW DEMAND (15 MIN BASIS)	106.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2808
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5678 BOILER ECO-6

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	16134.
PEAK DAY GAS CONSUMP., 1000 CU FT	136.
ELECTRICAL CONSUMPTION, KWH	233241.
PEAK KW DEMAND (15 MIN BASIS)	106.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	233241.
ON-PEAK KW DEMAND (15 MIN BASIS)	106.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2796
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



# QUOTATION

TO **EMC Engineers** /312-10350-0-0

PAGE 2 OF 2

ITEM	QUANTITY	DESCRIPTION	UNIT AMOUNT	AMOUNT
<p align="center"><b>SUGGESTED ACCESSORIES</b> (Quantities below are for each unit)</p>				
1		Bolted access manway in casing, approximately 16" Square, carbon steel construction.	300.	\$ 300.
1		1/2" Threaded connection for safety relief valve on header.	100.	\$ 100.
1		1/2" Threaded safety relief valve, Kunkie series 927.	555.	\$ 555.
<p>-- All prepaid and bill shipments will be at the billable freight amount plus a service charge of 10%. A service charge is not required for collect shipments or third party billing.</p>				
<p align="center">***** * KENTUBE is a member of the * * AMERICAN BOILER MANUFACTURERS ASSOCIATION * *****</p>				



4180 S. Elwood  
Tulsa, Oklahoma 74107  
Phone: (918) 446-4561  
FAX: (918) 446-4340

# QUOTATION

T O	EMC Engineers 2750 South Wadsworth Blvd. Denver, CO 80227	QUOTATION DATE 04/10/91	YOUR REFERENCE	SON REFERENCE 318-10350-0-0
	Attention: Mr. Dennis Jones	SHIPPING ESTIMATE 8 Weeks*	TERMS Net 30 Days	PAGE 1 OF 2
		SHIPPING DESTINATION	F.O.B.	Kentube Shop**

THANK YOU FOR YOUR INQUIRY. WE APPRECIATE THE OPPORTUNITY TO PROPOSE THE FOLLOWING:

ITEM	QUANTITY	DESCRIPTION	UNIT AMOUNT	AMOUNT
	2	<p>Kentube RETROMISER Fuel Economizer Cylindrical Model 201140, in accordance with the attached performance specifications.</p> <p><u>DESIGN FEATURES</u></p> <p>Finned tube unit; 4 Fins per inch; Vertical gas flow; Counter-current flow Fuel type: NATURAL GAS.</p> <p>Estimated Shipping Weight - 1768. LBS.</p> <p>Pressure parts to Section I of the ASME Boiler &amp; Pressure Vessel Code.</p> <p>External 2" insulation with weatherproof, corrugated casing is included.</p> <p>Threaded drain and vent connections included.</p> <p>Kentube manually operated sootblower, integral with unit, included. Requires 85 psig to 250 psig supply pressure.</p>		\$ 39312.

## ENCLOSURES

cc: Ted D. Miller Associates

NOTE: All shipping estimates are based on "after receipt of order" and "after final print approvals" as required. Shipments can often be improved upon request. Please contact Kentube. Prices firm for 30 days and subject to change thereafter. No provision is made for Federal, State or Municipal taxes. All orders are subject to acceptance or rejection by the Credit Department of Kentube and to the Terms of Sale attached.

YOUR REPRESENTATIVE IS:  
Ted D. Miller Associates  
2140 South Ivanhoe  
Denver, CO 80222

YOUR ORDER WILL RECEIVE OUR PROMPT ATTENTION

KENTUBE FABRICATED PRODUCTS

*Larry Wolfenbarger*  
Larry Wolfenbarger  
Product Sales Engineer

\*\*\*OPT\*\*\*  
CUSTOMER  
EMC Engineers  
PROPOSAL 318-10350-0-0  
RUN 00

KENTUBE  
4150 S. ELWOOD  
TULSA, OKLAHOMA

PRINTED 04/10/91  
TIME 09 HRS 06 MINS  
CUST. REFERENCE

CYLINDRICAL FUEL ECONOMIZER

MODEL 201140

OVERALL PERFORMANCE

COUNTER CURRENT FLOW  
FLUID CIRCULATED IN TUBES IS WATER  
HEAT EXCHANGED 532023. BTU/HR  
U EXTERNAL 6.938 BTU/HR-SQFT-F  
LMTD 160.3 DEG F

PERFORMANCE SPECIFICATIONS

	TUBE SIDE ↓	GAS SIDE ↑	
FLOW RATE	8420.	10307.	LB/HR
TEMP IN	180.0	500.0	DEG F
TEMP OUT	243.9	299.1	DEG F
PRES IN	180.0 PSIG	14.7	PSIA
PRES DROP	1.1 PSI	.77	IN WATER

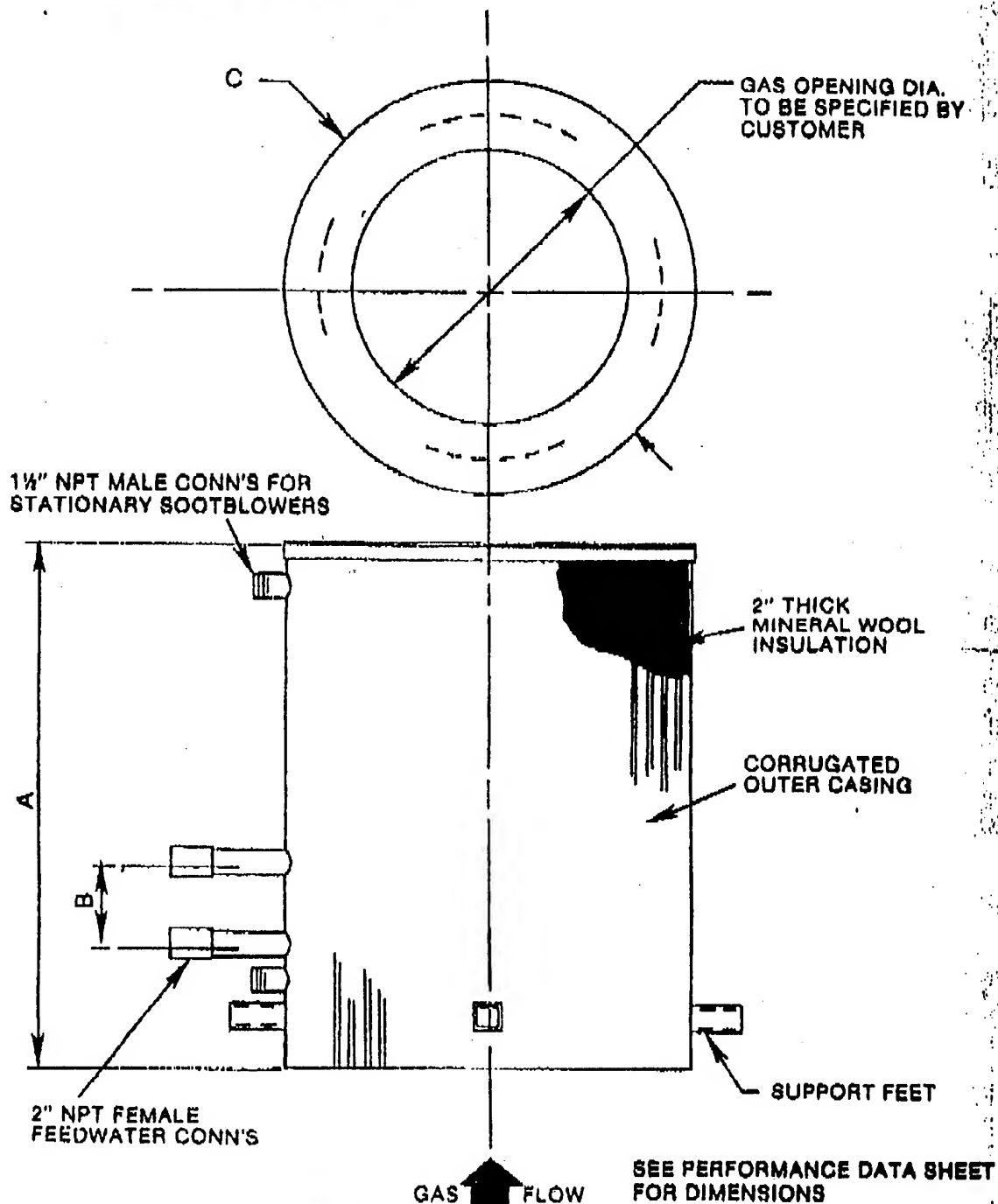
OVERALL CONSTRUCTION

VERTICAL GAS FLOW  
DIMENSIONS  
DIM A (HEIGHT) 7'-3/4"  
DIM B (NOZ C-C) 0'-5 1/2"  
DIM C (DIAMETER) 2'-9 3/4"  
DRAWING NO V-4  
SOOT BLOWERS ARE BUILT IN  
NOZZLE SIZE 2.0 IN  
SURFACE AREA 496. SQFT  
LIQUID WEIGHT 175. LB  
UNIT WEIGHT(DRY) 1768. LB

CONSTRUCTION SPECIFICATIONS  
TUBE SIDE

DESIGN PRESSURE	490.	PSI
TEST PRESSURE	735.	PSI
DESIGN TEMPERATURE	700.	DEG
TUBE OUTSIDE DIA	2.000	IN
MATERIAL	C/STL	
FIN THICKNESS	.040	IN
PITCH	4.00	FIN.
MATERIAL	C/STL	
INSULATION		
MATERIAL	MINERAL WOOL	
THICKNESS	2.0	IN

# Kentube cylindrical ~~horizontal~~ fuel economizer



4160 South Elwood • Tulsa, Oklahoma 47107  
918/446-4661 • Telex: 49-2353

CRFE-V4

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5678EC11

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ECONOMIZER AIR PREHEAT

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	29986.
B. SIOH	\$	1650.
C. DESIGN COST	\$	1800.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	30092.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	30092.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	196.	\$ 572.	17.52	10027.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		196.	\$ 572.		\$ 10027.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	0.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33) \$ 3309.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 572.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 10027.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .33  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 52.58

**CENTRAL PLANT 5900**

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 1  
**SYSTEM MODIFICATION:** ADD INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:** CHILLER 1, 2, 3, 4, AND 5

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-1, install instrumentation to facilitate efficient operation of chiller plant. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	1,886	2,743,132	--	9,362
ECO	1,886	2,224,028	--	7,591
Savings (Baseline-ECO)	0	519,104	0	1,772

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 1772 MMBtu/Yr X \$4.0141 /MMBtu = \$7,112 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$7,112 + \$0 = \$7,112 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$319 per year  
 Total: \$0 - \$319 = (\$319)per year

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total additional annual energy use due to operating chillers 3, 4, and 5  
more than necessary: 519,104 kWh/yr  
Total electrical consumption: 2,743,132 kWh/yr

PC-CUBE VERSION 2.0.3

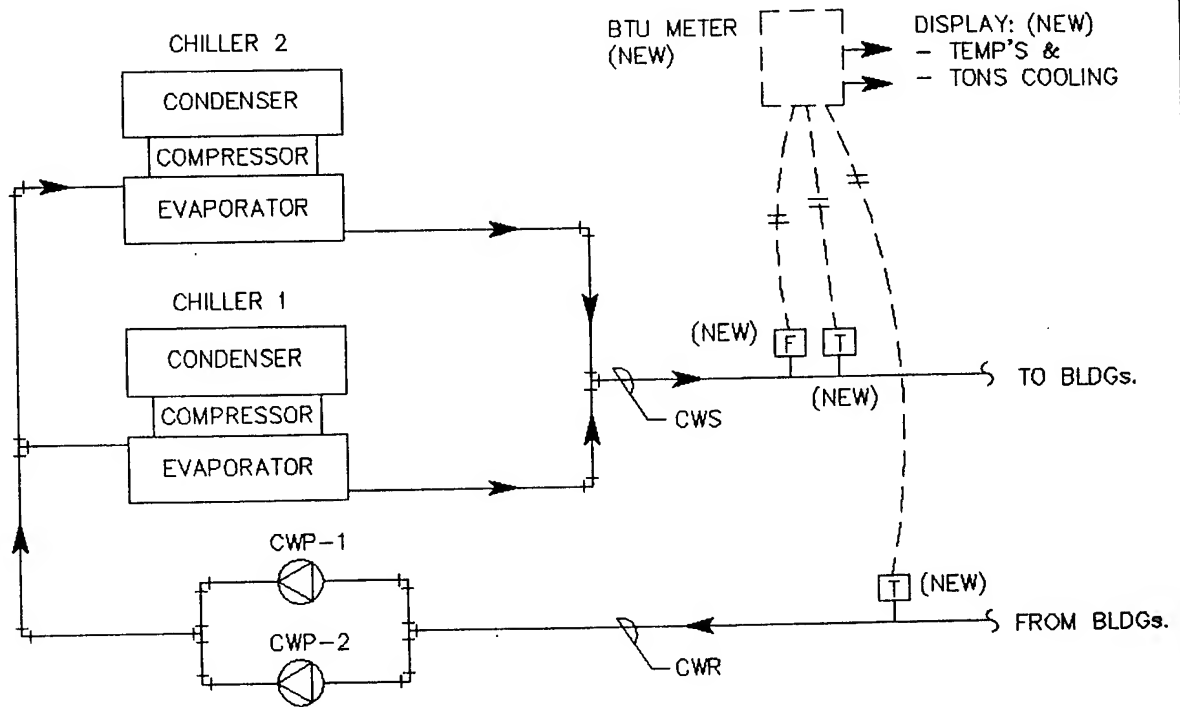
CENTRAL PLANT 5900

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# ECO-1, INSTRUMENTATION FOR CHILLER PLANT (TYPICAL)



[F] FLOW METER

[T] TEMPERATURE SENSORS

[C-ECO-1.DWG]

**INVITATION NO./CONTRACT NO.**

EFFECTIVE PRICING	DATE PREPARED
DATE APR. 91	04-Apr-91

EFFECTIVE PRICING  
DATE APR. 91

DATE PREPARED  
04-Apr-91

PROJECT	ENERGY SURVEY OF ARMY BOILER AND CHILLER
LOCATION	FT. SILL, OKLAHOMA

		CODE A	X	CODE B	CODE C
		OTHER _____			

OF THE

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C5900ECO

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER INSTRUMENTATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	5327.
B. SIOH	\$	293.
C. DESIGN COST	\$	320.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5346.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5346.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	1772.	\$ 7113.	8.78	62450.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		1772.	\$ 7113.		\$ 62450.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$ -319.
(1) DISCOUNT FACTOR (TABLE A)	9.11	
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$ -2906.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$ -2906.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$ 20609.	
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = _____		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ 6794.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 59544.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 11.14  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)  $SPB=1F/4$  .79

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 2  
**SYSTEM MODIFICATION:** CHILLER OPTIMIZATION, ADD INSTRUMENTATION  
**SYSTEMS TO MODIFY:** CHILLER 1, 2, 3, 4, AND 5

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-2, install instrumentation connected to EMCS for chiller optimization. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	1,886	2,743,132	--	9,362
ECO	1,877	2,203,702	--	7,521
Savings (Baseline-ECO)	9	539,430	0	1,841

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 1841 MMBtu/Yr X \$4.0141 /MMBtu = \$7,390 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$7,390 + \$0 = \$7,390 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 9 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$193 per year  
 Maintenance: = (-) \$1,188 per year  
**Total: \$193 - \$1,188 = (\$995)per year**

## PC-CUBE VERSION 2.0.3

## CENTRAL PLANT 5900 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total additional annual energy use due to operating chillers 3, 4, and 5  
more than necessary: 519,104 kWh/yr  
Total electrical consumption: 2,743,132 kWh/yr

PC-CUBE VERSION 2.0.3

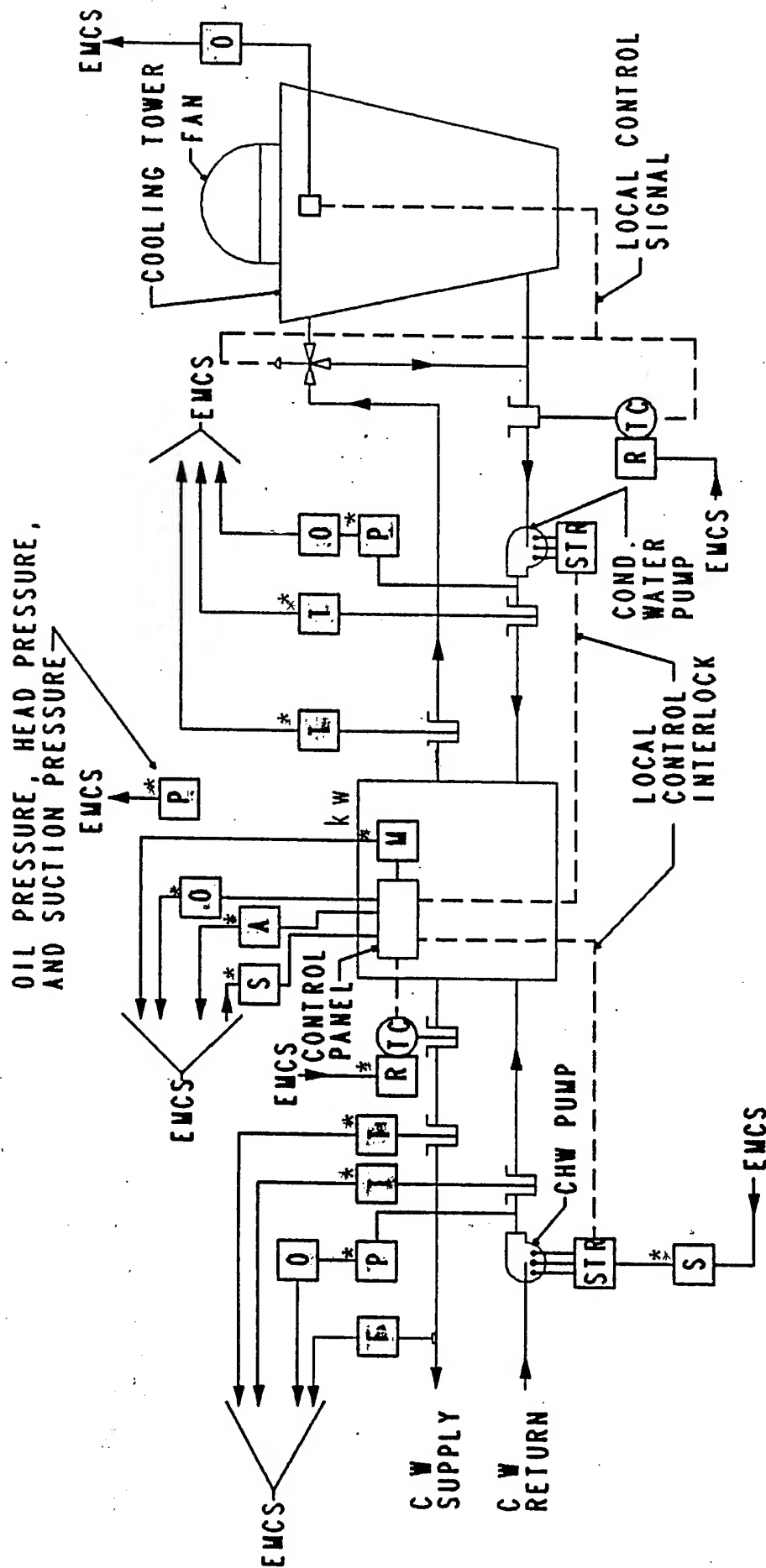
CENTRAL PLANT 5900 CHILLER ECO-2

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2203702.
PEAK KW DEMAND (15 MIN BASIS)	1877.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2203702.
ON-PEAK KW DEMAND (15 MIN BASIS)	1877.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2782
CHILLER 3	973
CHILLER 4	482
CHILLER 5	101
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.





Water cooled chiller

\* - Points included on proposed EMCS design, existing.  
All other points are new.



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: C5900ECO  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER OPTIMIZATION  
 ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	19798.
B. SIOH	\$	1089.
C. DESIGN COST	\$	1188.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	19868.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	19868.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	1857.	\$ 7454.	8.78	65446.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		1857.	\$ 7454.		\$ 65446.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -9064.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -9064.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 21597.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 6459.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 56382.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 2.84  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 3.08

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-3  
**SYSTEM MODIFICATION:** MINOR RENOVATION & ANNUAL MAINTENANCE  
**SYSTEMS TO MODIFY:** CHILLER 1, 2, 3, 4, AND 5

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-3, renovate or replace existing chillers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	1,886	2,743,000	--	9,362
ECO	1,732	2,025,000	--	6,911
Savings (Baseline-ECO)	154	718,000	0	2,451

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	2451 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$9,837 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$9,837 +</b>	<b>\$0</b>	<b>=</b>	<b>\$9,837 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	154 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$3,302 per year		
Maintenance:	= (-)		\$3,000 per year		
<b>Total:</b>	<b>\$3,302</b>	<b>-</b>	<b>\$3,000</b>	<b>=</b>	<b>\$302 per year</b>

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total additional annual energy use due to operating chillers 3, 4, and 5  
 more than necessary: 519,104 kWh/yr  
 Total electrical consumption: 2,743,132 kWh/yr

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 CHILLER ECO-3

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2025466.
PEAK KW DEMAND (15 MIN BASIS)	1732.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2025466.
ON-PEAK KW DEMAND (15 MIN BASIS)	1732.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	1975
CHILLER 3	765
CHILLER 4	143
CHILLER 5	63
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C5900EC3

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER MAINTENANCE

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	44749.
B. SIOH	\$	2462.
C. DESIGN COST	\$	2685.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	44906.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	44906.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	679.	\$ 2726.	8.78	23937.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		679.	\$ 2726.		\$ 23937.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	302.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	2751.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ 2751.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33) \$ 7899.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 3028.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 26688.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .59  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 14.83

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	1,890	0	0	0

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	0 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$0 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$0</b>	<b>=</b>	<b>\$0 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	1890 kW/month	X	\$1.787 /kW	X	12 months/year	
	= (+)		\$40,529			per year
Maintenance:	= (-)		\$0			per year
<b>Total:</b>	<b>\$40,529</b>	<b>-</b>	<b>\$0</b>	<b>=</b>	<b>\$40,529</b>	<b>per year</b>

[ECO-SHT.WK3]

# A new application of an old idea that can cut air conditioning energy costs in half.

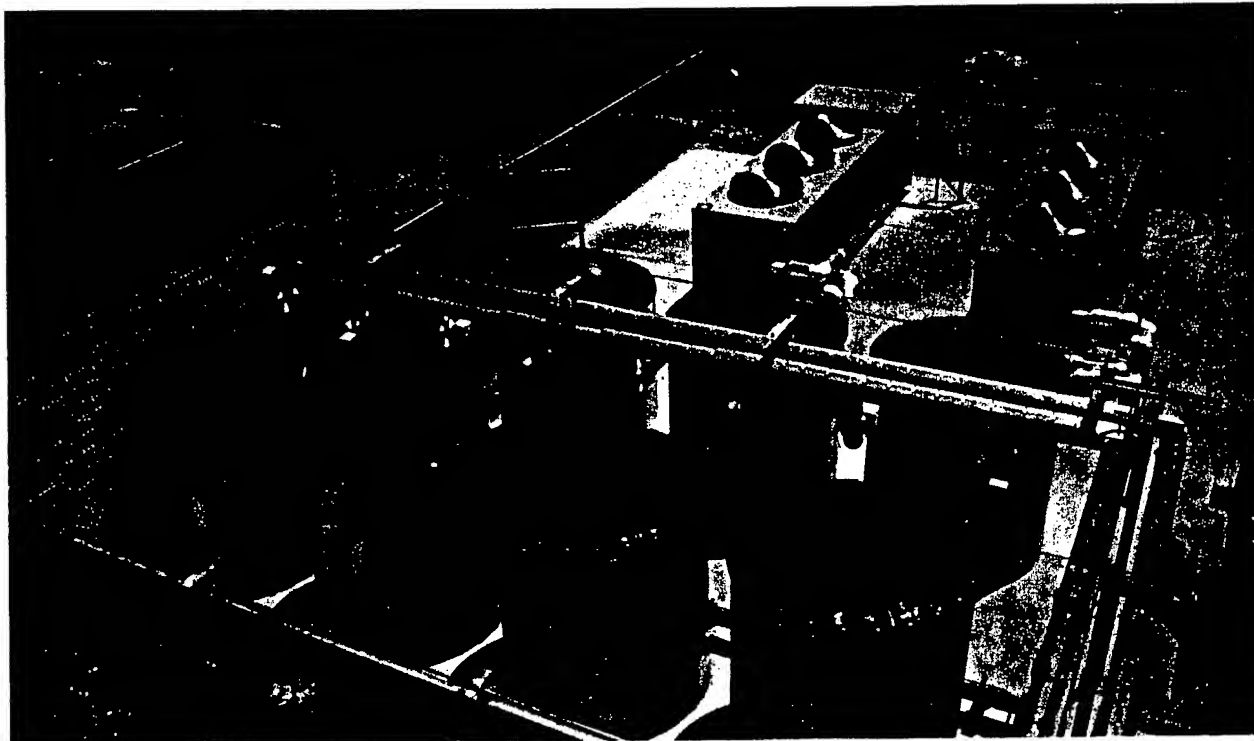
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

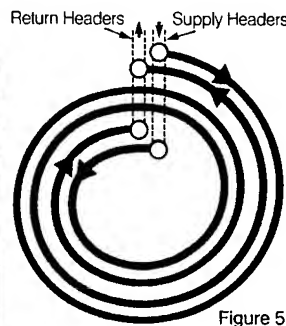
Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes - 90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.



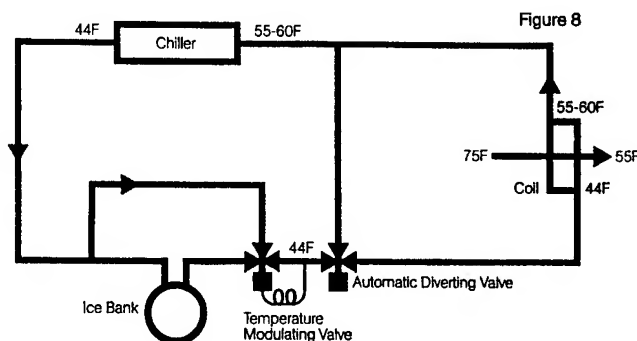
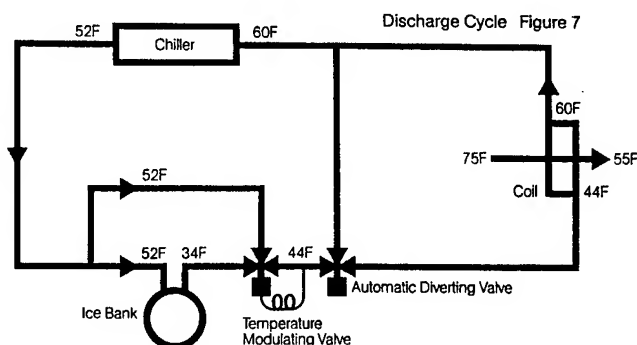
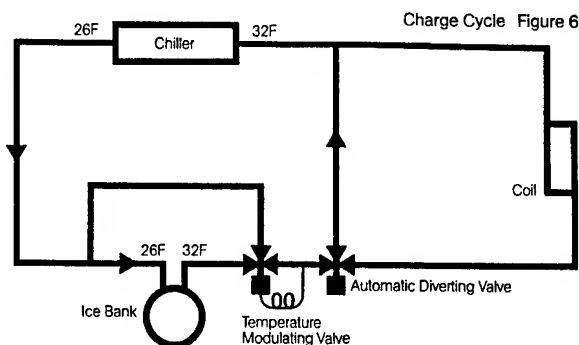
Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.



The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's Dowtherm® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5900EC4

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM

ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	504000.
B. SIOH	\$	27720.
C. DESIGN COST	\$	30240.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	505764.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	505764.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	40529.
(1) DISCOUNT FACTOR (TABLE A)			11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	472163.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	472163.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)		\$	0.
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=			.00
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 40529.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 472163.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .93  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 12.48

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(A)  
**SYSTEM MODIFICATION:** TWO SPEED FANS FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER #1

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	42,802	--	146
ECO	--	26,887	--	92
Savings (Baseline-ECO)	0	15,915	0	54

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 54 MMBtu/Yr X \$4.0141 /MMBtu = \$218 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$218 + \$0 = \$218 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$0 - \$0 = \$0 per year**

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input (part 7). The control sequence is:

- 0-50% load, fan 1, half speed cycling.
- 50-100% load, fan 1 full speed cycling.

kWh per bin, for % design loads less than 50% load = (fan 1 power kW) \* 14% \* (%design load / 50) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 50% to 100% load = ( fan 1 power kW \* ((% design load)/ 100) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 5900 (COOLING TOWER 1 ONLY)	
DESIGN CONDITIONS	
– WBT (DB, DEG F)	78
– WATER FLOW (gpm)	1200
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
– AIR FLOW (LBS/MIN)	4980
HEAT REJECTION CAPACITY (Btu/min)	
	99600
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	41.58
TOTAL ENTHALPY	61.58
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	75198
MOTOR DATA	
– FAN 1 POWER (kW)	19.2
– FAN 2 POWER (kW)	0
– FAN 3 POWER (kW)	0
– FAN 4 POWER (kW)	0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET – BULB AVERAGES (4 hour bins)						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	78
MAY	57.1	56.6	61.2	63.9	63	59.4	78
JUNE	66.8	66.6	69.9	71	70.5	68.2	78
JULY	70.8	70.9	74.5	76	74.9	72.6	78
AUGUST	66.9	67	71	72	71	68.5	78
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	78
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	78

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	41.58
MAY	24.53	24.21	27.28	29.23	28.57	26.06	41.58
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	41.58
JULY	34.77	34.86	38.14	39.57	38.52	36.37	41.58
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	41.58
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	41.58
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	41.58

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD
	1-4	5-8	9-12	13-16	17-20	21-24	(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.9	0.9	0.9	0.9	0.9	0.9	15953000
JUNE	0.9	0.9	0.9	0.9	0.9	0.9	19533000
JULY	0.9	0.9	0.9	0.9	0.9	0.9	19533000
AUGUST	0.9	0.9	0.9	0.9	0.9	0.9	19533000
SEPTEMBER	0.9	0.9	0.9	0.9	0.9	0.9	19533000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.9	1.9	1.7	1.6	1.7	1.8	31
JUNE	1.5	1.5	1.4	1.3	1.4	1.4	30
JULY	1.3	1.3	1.2	1.1	1.2	1.3	31
AUGUST	1.5	1.5	1.3	1.3	1.3	1.4	31
SEPTEMBER	1.6	1.6	1.5	1.4	1.5	1.6	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

% DESIGN LOAD							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	39.7	39.3	42.9	45.4	44.5	41.4	31
JUNE	59.8	59.5	65.3	67.6	66.5	62.1	30
JULY	67.1	67.4	76.8	81.8	78.1	71.4	31
AUGUST	59.9	60.1	67.6	69.9	67.6	62.6	31
SEPTEMBER	57.2	57.0	61.4	63.2	60.7	58.0	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

SINGLE SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	945	937	1020	1082	1060	985	
JUNE	1377	1370	1504	1557	1532	1431	
JULY	1598	1604	1828	1947	1858	1700	
AUGUST	1427	1430	1609	1664	1609	1491	
SEPTEMBER	1319	1312	1414	1456	1399	1335	
OCTOBER	0	0	0	0	0	0	
TOTAL	6666	6653	7376	7706	7459	6942	42802

TWO SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	265	262	286	303	297	276	
JUNE	773	759	1027	1133	1083	880	
JULY	1149	1160	1609	1847	1669	1352	
AUGUST	806	813	1171	1281	1171	935	
SEPTEMBER	656	643	847	930	816	689	
OCTOBER	0	0	0	0	0	0	
TOTAL	3649	3638	4939	5494	5036	4132	26887



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 5900EC5A  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER  
 ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	7729.
B. SIOH	\$	425.
C. DESIGN COST	\$	464.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	7756.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	7756.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	54.	\$ 218.	11.37	2479.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		54.	\$ 218.		\$ 2479.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	0.
(1) DISCOUNT FACTOR (TABLE A)	11.65	
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	0.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	0.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	818.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 218.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 2479.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .32  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 35.57

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	42,802	--	146
ECO	--	21,627	--	74
Savings (Baseline-ECO)	0	21,175	0	72

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 72 MMBtu/Yr X \$4.0141 /MMBtu = \$290 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$290 + \$0 = \$290 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$425 per year  
**Total: \$0 - \$425 = (\$425) per year**

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

$(\text{Total exit air design enthalpy minus average monthly enthalpy, part 2}) / (\text{entering air design enthalpy})$

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

$(\% \text{ load on plant, part 3} * \text{monthly peak load, part 3}) / (\text{Highest monthly peak load, part 3}) * (1 / \text{ratio of monthly enthalpy, part 4})$

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

$\text{kWh per bin} = (\text{total fan power kW}) * (\% \text{ design load, part 5} * 4 \text{ hours per bin} * \text{days per month})$

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input (part 7). The control sequence is:

- 0-50% load, fan 1, half speed cycling.
- 50-100% load, fan 1 full speed cycling.

kWh per bin, for % design loads less than 50% load = (fan 1 power kW) \* 14% \* (%design load / 50) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 50% to 100% load = ( fan 1 power kW \* ((% design load)/ 100) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 5900 (COOLING TOWER 1 ONLY)	
DESIGN CONDITIONS	
– WBT (DB, DEG F)	78
– WATER FLOW (gpm)	1200
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
– AIR FLOW (LBS/MIN)	4980
HEAT REJECTION CAPACITY (Btu/min)	
	99600
DELTA ENTHALPY (Btu/lb)	
	20
DESIGN ENTHALPY (Btu/lb)	
	41.58
TOTAL ENTHALPY	
	61.58
EXIT AIR WB (LOOK UP)	
	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	
	15.1
100% DESIGN CFM @ WB	
	75198
MOTOR DATA	
– FAN 1 POWER (kW)	19.2
– FAN 2 POWER (kW)	0
– FAN 3 POWER (kW)	0
– FAN 4 POWER (kW)	0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET-BULB AVERAGES (4 hour bins)						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	78
MAY	57.1	56.6	61.2	63.9	63	59.4	78
JUNE	66.8	66.6	69.9	71	70.5	68.2	78
JULY	70.8	70.9	74.5	76	74.9	72.6	78
AUGUST	66.9	67	71	72	71	68.5	78
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	78
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	78

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	41.58
MAY	24.53	24.21	27.28	29.23	28.57	26.06	41.58
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	41.58
JULY	34.77	34.86	38.14	39.57	38.52	36.37	41.58
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	41.58
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	41.58
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	41.58

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD
	1-4	5-8	9-12	13-16	17-20	21-24	(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.9	0.9	0.9	0.9	0.9	0.9	15953000
JUNE	0.9	0.9	0.9	0.9	0.9	0.9	19533000
JULY	0.9	0.9	0.9	0.9	0.9	0.9	19533000
AUGUST	0.9	0.9	0.9	0.9	0.9	0.9	19533000
SEPTEMBER	0.9	0.9	0.9	0.9	0.9	0.9	19533000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER MONTH OPER.
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.9	1.9	1.7	1.6	1.7	1.8	31
JUNE	1.5	1.5	1.4	1.3	1.4	1.4	30
JULY	1.3	1.3	1.2	1.1	1.2	1.3	31
AUGUST	1.5	1.5	1.3	1.3	1.3	1.4	31
SEPTEMBER	1.6	1.6	1.5	1.4	1.5	1.6	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

% DESIGN LOAD							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	39.7	39.3	42.9	45.4	44.5	41.4	31
JUNE	59.8	59.5	65.3	67.6	66.5	62.1	30
JULY	67.1	67.4	76.8	81.8	78.1	71.4	31
AUGUST	59.9	60.1	67.6	69.9	67.6	62.6	31
SEPTEMBER	57.2	57.0	61.4	63.2	60.7	58.0	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

SINGLE SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	945	937	1020	1082	1060	985	
JUNE	1377	1370	1504	1557	1532	1431	
JULY	1598	1604	1828	1947	1858	1700	
AUGUST	1427	1430	1609	1664	1609	1491	
SEPTEMBER	1319	1312	1414	1456	1399	1335	
OCTOBER	0	0	0	0	0	0	
TOTAL	6666	6653	7376	7706	7459	6942	42802

TWO SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	265	262	286	303	297	276	
JUNE	773	759	1027	1133	1083	880	
JULY	1149	1160	1609	1847	1669	1352	
AUGUST	806	813	1171	1281	1171	935	
SEPTEMBER	656	643	847	930	816	689	
OCTOBER	0	0	0	0	0	0	
TOTAL	3649	3638	4939	5494	5036	4132	26887

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	186	181	234	279	263	211	
JUNE	615	606	801	889	847	689	
JULY	901	910	1348	1628	1415	1083	
AUGUST	640	645	919	1017	919	731	
SEPTEMBER	540	532	666	726	644	561	
OCTOBER	0	0	0	0	0	0	
TOTAL	2882	2874	3968	4539	4088	3275	21627



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5900EC5B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	7079.
B. SIOH	\$	390.
C. DESIGN COST	\$	425.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	7105.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	7105.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	72.	\$ 290.	11.37	3298.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		72.	\$ 290.		\$ 3298.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-425.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-4951.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-4951.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1088.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -135.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -1653.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -23  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -52.66

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.  
 It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	28	42,400	0	145

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 145 MMBtu/Yr X \$4.0141 /MMBtu = \$581 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$581 + \$0 = \$581 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 28 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$600 per year  
 Maintenance: = (-) \$0 per year  
 Total: \$600 - \$0 = \$600 per year

[ECO-SHT.WK3]

# **HIGH EFFICIENCY MOTOR REPLACEMENT**

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR
5900	CWP-1	50.0	62.5	60	0.82	460	91.35%	93.00%	0.76	3672	2800	\$55
	CWP-2	60.0	69	53.6	0.88	460	92.52%	94.50%	0.85	2215	1884	\$44
	CWP-3	60.0	75	62	0.83	460	89.92%	94.50%	2.22	810	1796	\$72
	CWP-4	75.0	93	82.3	0.87	460	86.79%	93.60%	4.78	419	2003	\$130
	CWP-5	60.0	77	67	0.80	460	91.43%	94.50%	1.51	84	127	\$34
	CNWP-1	25.0	32	26.3	0.82	460	89.42%	91.70%	0.48	3672	1746	\$34
	CNWP-2	30.0	39.8	35.6	0.78	460	90.25%	92.40%	0.57	2215	1266	\$30
	CNWP-3	30.0	38	35.6	0.82	460	89.71%	92.40%	0.76	810	615	\$25
	CNWP-4	40.0	52	42.9	0.78	460	92.34%	93.00%	0.21	419	86	\$6
	CNWP-5	30.0	38	32	0.83	460	89.06%	92.40%	0.86	84	72	\$19
	CTM-1	25.0	31	27.2	0.87	460	86.79%	91.70%	1.16	2229	2592	\$60
	CTM-2	NI	NI	NI								
	CTM-3	NI	NI	NI								
	CTM-4	NI	NI	NI								
	CTM-5	20.0	24	24.6	0.87	460	89.69%	91.00%	0.27	84	23	\$6
	HWP(ret)-1	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34
	HWP(ret)-2	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33
	HWP(ret)-3	2.0	6.2	5.5	0.87	230	69.43%	84.00%	0.48	3443	1639	\$33
	HWP(ret)-4	2.0	6.2	5.3	0.87	230	69.43%	84.00%	0.46	2445	1122	\$25
	HWP(ret)-5	2.0	6.3	5.4	0.87	460	34.17%	84.00%	6.50	1720	11179	\$293
	HWP(sup)-6	2.0	6.2	5.5	0.87	230	69.43%	84.00%	0.48	910	433	\$16
	HWP(sup)-7	15.0	19.8	16.7	0.87	460	81.53%	90.20%	1.36	3624	4945	\$97
	HWP(sup)-8	20.0	24	15.2	0.87	460	89.69%	91.00%	0.17	2174.4	369	\$9
	HWP(sup)-9	20.0	25	15.6	0.86	460	87.51%	91.00%	0.47	2174.4	1015	\$24
	HWP(sup)-10	15.0	19.8	16.7	0.79	460	89.79%	90.20%	0.05	1449.6	77	\$
	HWP(sup)-11	25.0	30	29	0.93	460	83.90%	91.70%	2.18	1449.6	3158	\$90
	<b>DEMAND CREDIT</b>			<b>\$590</b>	<b>MMBtu</b>		<b>145</b>	<b>TOTAL</b>	<b>28</b>		<b>42400</b>	<b>\$1,171</b>
6003	CWP-1	NI	NI	NI								
	CWP-2	50.0	62.5	44.6	0.81	460	92.48%	93.00%	0.18	3672	645	\$13
	CWP-3	50.0	62.5	46.4	0.87	460	86.10%	93.00%	2.77	3672	10181	\$199
	CNWP-1	NI	NI	NI								
	CNWP-2	30.0	37	32	0.84	460	90.38%	92.40%	0.52	3672	1905	\$37
	CNWP-3	30.0	37	31	0.87	460	87.26%	92.40%	1.37	3672	5029	\$98
	CTM-1	50.0	63	56.3	0.87	460	85.41%	93.00%	3.73	1087	4051	\$135
	CTM-2	50.0	63	56.3	0.87	460	85.41%	93.00%	3.73	1087	4051	\$135
	<b>DEMAND CREDIT</b>			<b>\$264</b>	<b>MMBtu</b>		<b>88</b>	<b>TOTAL</b>	<b>12</b>		<b>25861</b>	<b>\$618</b>

# COST ESTIMATE ANALYSIS

PROJECT		LOCATION		INFORMATION NO./CONTRACT NO.				EFFECTIVE PRICING		DATE PREPARED	
ENERGY SURVEY OF ARMY BOILER AND CHILLER		FT. SILL, OKLAHOMA		DACA 59-90-C-0087				DATE APR. 91		10-Apr-91	
				CODE A <input type="checkbox"/> CODE B <input type="checkbox"/> CODE C <input type="checkbox"/>				DRAWING NO.		SHT OF	
				OTHER <input type="checkbox"/>							
MOTOR REP. ECO		BLDG. 5900		LABOR		EQUIPMENT		MATERIAL		ESTIMATOR KC	
HIGH EFF. MOTOR REPLACEMENT		TASK DESCRIPTION		Quantity		Total Hrs		Unit Price		Cost	
		No. Of Units	Unit Meas	MH/ Unit	Total Hrs	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost
CWP-1	50.0 HP MOTOR	1	EA	9.0	9.0	20	176	2579.0	2579.00		\$2,755
CWP-2	60.0 HP MOTOR	1	EA	10.3	10.3	20	201	3235.0	3235.00		\$3,436
CWP-3	60.0 HP MOTOR	1	EA	10.3	10.3	20	201	3235.0	3235.00		\$3,436
CWP-4	75.0 HP MOTOR	1	EA	12.0	12.0	20	235	3853.0	3853.00		\$4,088
CWP-5	60.0 HP MOTOR	1	EA	10.3	10.3	20	201	3235.0	3235.00		\$3,436
CNWP-1	25.0 HP MOTOR	1	EA	5.8	5.8	20	113	1396.0	1396.00		\$1,509
CNWP-2	30.0 HP MOTOR	1	EA	6.0	6.0	20	117	1639.0	1639.00		\$1,756
CNWP-3	30.0 HP MOTOR	1	EA	6.0	6.0	20	117	1639.0	1639.00		\$1,756
CNWP-4	40.0 HP MOTOR	1	EA	7.2	7.2	20	141	2212.0	2212.00		\$2,353
CNWP-5	30.0 HP MOTOR	1	EA	6.0	6.0	20	117	1639.0	1639.00		\$1,756
CTM-1	25.0 HP MOTOR	1	EA	5.8	5.8	20	113	1396.0	1396.00		\$1,509
HWP(ret)-1	2.0 HP MOTOR	1	EA	3.2	3.2	20	63	359.0	359.00		\$422
HWP(ret)-2	2.0 HP MOTOR	1	EA	3.2	3.2	20	63	359.0	359.00		\$422
HWP(ret)-3	2.0 HP MOTOR	1	EA	3.2	3.2	20	63	359.0	359.00		\$422
HWP(ret)-4	2.0 HP MOTOR	1	EA	3.2	3.2	20	63	359.0	359.00		\$422
HWP(ret)-5	2.0 HP MOTOR	1	EA	3.2	3.2	20	63	359.0	359.00		\$422
HWP(sup)-6	2.0 HP MOTOR	1	EA	3.2	3.2	20	63	359.0	359.00		\$422
HWP(sup)-7	15.0 HP MOTOR	1	EA	4.5	4.5	20	88	985.0	985.00		\$1,073
HWP(sup)-8	20.0 HP MOTOR	1	EA	5.5	5.5	20	109	1189.0	1189.00		\$1,298
HWP(sup)-9	20.0 HP MOTOR	1	EA	5.5	5.5	20	109	1189.0	1189.00		\$1,298
HWP(sup)-10	15.0 HP MOTOR	1	EA	4.5	4.5	20	88	985.0	985.00		\$1,073
HWP(sup)-11	25.0 HP MOTOR	1	EA	5.8	5.8	20	113	1396.0	1396.00		\$1,509
SUBTOTAL											
OVERHEAD, BOND		16%					\$2,619		\$33,956		\$36,575
PROFIT		10%					\$419		\$5,433		\$5,852
COST SUB-TOTAL							\$262		\$3,396		\$3,657
CONTINGENCY		20%					\$3,300		\$42,785		\$46,084
SUBTOTAL							\$680		\$8,557		\$9,217
S&A							\$3,980		\$51,341		\$55,301
TOTAL THIS SHEET		5.5%					\$218		\$2,824		\$3,042
							\$4,177		\$54,165		\$58,343

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5900EC6

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	55301.
B. SIOH	\$	3042.
C. DESIGN COST	\$	3318.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	55495.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	55495.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	145.	\$ 581.	11.37	6604.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		145.	\$ 581.		\$ 6604.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	600.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	6990.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	6990.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	2179.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=		.16
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 1181.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 13594.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .24  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 47.00

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-7  
**SYSTEM MODIFICATION:** INSTALL INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-7, install instrumentation to facilitate efficient operation of boiler plant. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	0	161	161

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	161 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$470 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$470</b>	<b>=</b>	<b>\$470 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	=	(+)			\$0 per year
Maintenance:	=	(-)			\$306 per year
<b>Total:</b>	<b>\$0</b>	<b>-</b>	<b>\$306</b>	<b>=</b>	<b>(\$306) per year</b>

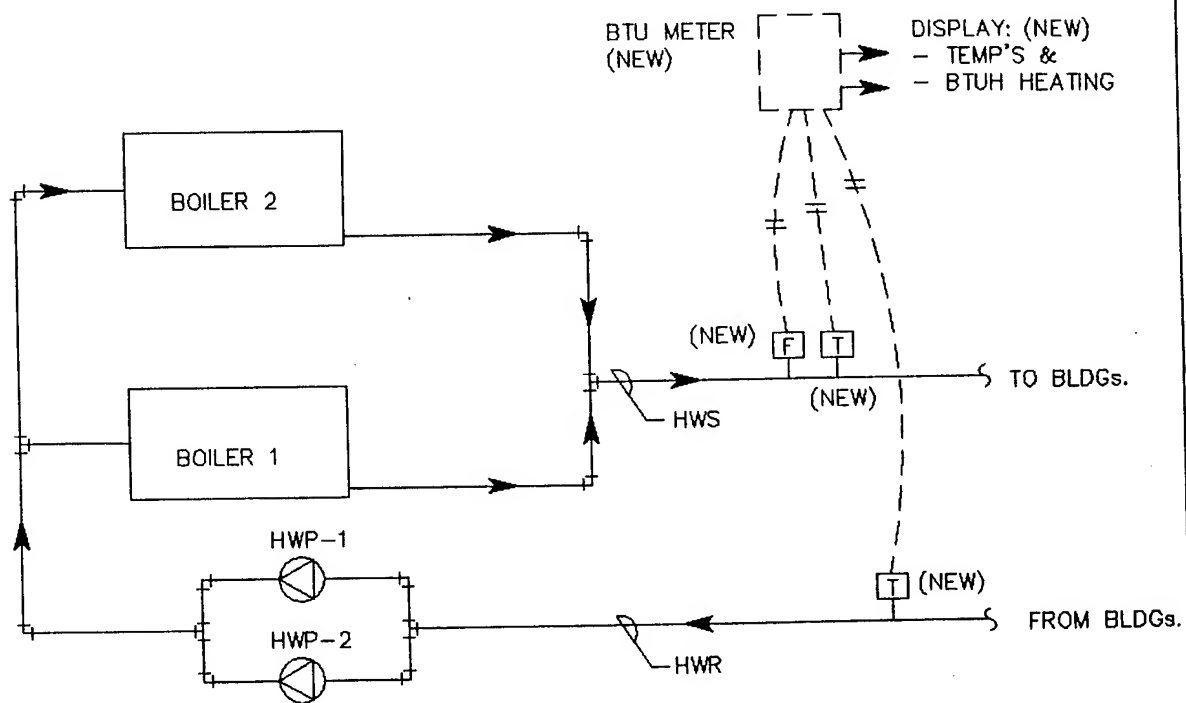
[ECO-SHT.WK3]

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS STANDBY SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0	0	\$150.74
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	51.62	\$160.09
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.82	\$159.27
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0	0	
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0	0	
TOTAL								2160	160.99	\$470.10
6003	1	STEAM-12	KEWANEE	L39-350-605	11.72	9.41	0.0941	0	0	
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0	0	
	3	STEAM-12	KEWANEE	L36-350-605	11.72	9.37	0.0937	720	67.45	\$196.96
	TOTAL							720	67.45	\$196.96
730	1	STEAM-12	KEWANEE	CAT#71286-KX	7.75	6.16	0.0616	0	0	
	2	STEAM-12	KEWANEE	CAT#71286-KX	7.75	6.16	0.0616	720	44.34	\$129.47
	3	STEAM-12	KEWANEE	CAT#71286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANEE	CAT#71280-KG-06	2.66	2.11	0.0211	0	0	
TOTAL								1440	88.84	\$259.43
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3562	1.80	1.40	0.0140	0	0	
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.77	0.0277	0	0	
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.62	\$60.21
TOTAL								720	20.62	\$60.21
5676	1	HW	AMERICAN STANDARD	PF 515	2.44	1.80	0.0180	720	12.93	\$37.76
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0	0	
TOTAL								720	12.93	\$37.76
5678	1	HW	BRUNHAM	PF 514	2.27	1.50	0.0150	720	10.79	\$31.50
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0	0	
TOTAL								720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.61	1.29	0.0129	0	0	
	2	HW	RAY-PAK	EA 200ITB	1.61	1.22	0.0122	0	0	
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0	0	
TOTAL								720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	0	0	
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	0.00	0.0000	0	0	
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
TOTAL								720	60.73	\$177.33

[BOILERS.WK3]

# ECO-7, INSTRUMENTATION FOR BOILER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[B-ECO-7.DWG]

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: B5900E12  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER INSTRUMENTATION  
 ANALYSIS DATE: 04-12-91 ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	5096.
B. SIOH	\$	281.
C. DESIGN COST	\$	306.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5115.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5115.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	161.	\$ 470.	12.48	5867.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		161.	\$ 470.		\$ 5867.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)	9.11	\$ -306.
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$ -2788.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -2788.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33) \$ 1936.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 164.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 3079.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .60  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 31.16

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-8  
**SYSTEM MODIFICATION:** BOILER OPTIMIZATION, CONTROL & INSTRUMENTATION  
**SYSTEMS TO MODIFY:** BOILER 1 THROUGH 6

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-8, install instrumentation connected to EMCS for boiler optimization. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	172,255	172,255
ECO	--	--	166,098	166,098
Savings (Baseline-ECO)	0	0	6,157	6,157

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 6157 MMBtu/Yr X \$2.92 /MMBtu = \$17,978 per year  
 Total Energy Cost Savings: \$0 + \$17,978 = \$17,978 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$2,745 per year  
 Total: \$0 - \$2,745 = (\$2,745) per year

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total additional annual energy use due to operating chillers 3, 4, and 5  
more than necessary: 519,104 kWh/yr  
Total electrical consumption: 2,743,132 kWh/yr

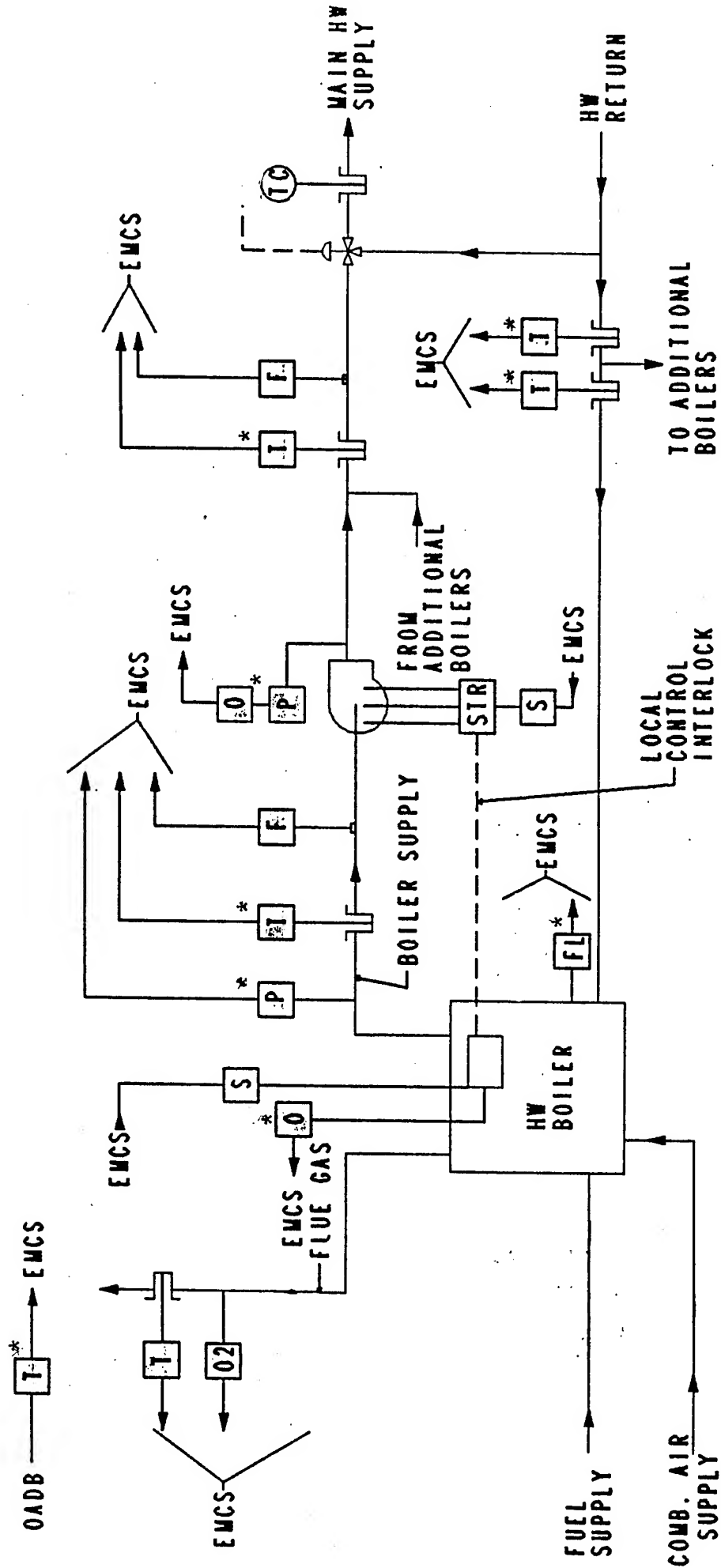
PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BOILER ECO-2

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	166098.
PEAK DAY GAS CONSUMP., 1000 CU FT	1642.
ELECTRICAL CONSUMPTION, KWH	2213589.
PEAK KW DEMAND (15 MIN BASIS)	1874.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2213589.
ON-PEAK KW DEMAND (15 MIN BASIS)	1874.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	101
CHILLER 6	0
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3311
BOILER 4	2392
BOILER 5	1678
BOILER 6	745
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



Hot water boiler

\* - Points included on proposed EMCS design, existing.  
All other points are new.

→ EMCS SIGNAL TRANSMITTED TO EMCS

← EMCS SIGNAL TRANSMITTED FROM EMCS

[A]	ALARM CONTACT SIGNAL
[E]	ECONOMIZER CONTROL INTERFACE
[F]	FLOW INDICATION
[FL]	FLAME INDICATION
[H]	HUMIDITY INDICATION
[P]	PRESSURE INDICATION
[LV]	LEVEL INDICATION
[M]	METER
[O]	ON-OFF STATUS SIGNAL
[DP]	DIFFERENTIAL PRESSURE SWITCH
[R]	CONTROLLER RESET INTERFACE
[S]	START-STOP INTERFACE
[T]	TEMPERATURE INDICATION
[V]	VENTILATION/RECIRCULATION CONTROL
[PS]	POSITION
[O <sub>2</sub> ]	FLUE GAS ANALYSIS, OXYGEN
[Co]	FLUE GAS ANALYSIS, CARBON MONOXIDE

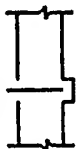
[FD]

[DS]

[TC]

[PC]

[STR]



CHW

EA

SA

RA

OA

MA

WB

DB

OAD

RAD

EAD

MZD

RH

FURNACE DRAFT DIFFERENTIAL PRESSURE

HIGH-LOW DEMAND SIGNAL SELECTOR

TEMPERATURE CONTROLLER

PRESSURE CONTROLLER

MOTOR STARTER

SENSOR INSTALLED IN THERMOMETER WELL

SENSOR INSTALLED IN DUCT OR PLENUM

CHILLED WATER

EXHAUST AIR

SUPPLY AIR

RETURN AIR

OUTSIDE AIR

MIXED AIR

WET BULB

DRY BULB

OUTSIDE AIR DAMPER

RETURN AIR DAMPER

EXHAUST AIR DAMPER

MULTIZONE DAMPER

RELATIVE HUMIDITY

Symbols and Abbreviations

## COST ESTIMATE ANALYSIS

COST ESTIMATE ANALYSIS								INVITATION NO./CONTRACT NO.						EFFECTIVE PRICING		DATE PREPARED	
PROJECT ENERGY SURVEY OF ARMY BOILER AND CHILLER		DACA 59-90-C-0087							DATE APR. 91		12-Apr-91						
LOCATION FT. SILL, OKLAHOMA		CODE A X CODE B CODE C		OTHER		DRAWING NO.		SHT OF									
BOILER ECO BLDG. 5900		LABOR		EQUIPMENT		MATERIAL		ESTIMATOR KC		CHECKED BY CEL							
OPTIMIZE BOILER SEQUENCE		Quantity		Unit Price		Unit Price		TOTAL		SHIPPING							
TASK DESCRIPTION		No. Of Units	MH/ Unit	Total Hrs	Unit Price	Cost	Unit Price	Cost	Unit Wt	Total Wt							
INSTRUMENTATION FOR 2 HW BOILERS																	
HWS TEMPERATURE SENSOR *		6 EA			176	\$1,056		\$328 \$1,968		\$4,992							
HWR TEMPERATURE SENSOR *		6 EA			176	\$1,056		\$328 \$1,968		\$4,992							
HWP ST/SP		11 LS			39	\$431		\$226 \$2,486		\$2,917							
DP (LIQUID) PUMP STATUS *		11 LS			155	\$1,705		\$205 \$2,255		\$6,215							
BOILER ST/SP		6 EA	2.0	12.0	20	\$235		\$226 \$1,356		\$1,591							
FID PANEL & ACCESSORIES *		1 LS			208	\$208		\$3,681 \$7,570									
FID SOFTWARE COMMISSIONING		1 EA	6.0	6.0	45	\$270				\$270							
FID TESTING		1 EA	6.0	6.0	45	\$270				\$270							
INST. FLOW METER		1 EA	3.5	3.5	20	\$69		500 \$500		\$569							
STACK O2 SENSOR		6 LS			338	\$2,028		\$3,483 \$20,898		\$22,926							
STACK TEMP. SENSOR		6 EA	4.0	24.0	20	\$470		\$207 \$1,239		\$1,709							
CREDIT FROM EMCS PROJECT *																	
SUBTOTAL OVERHEAD, BOND PROFIT		16.0% 10.0%				\$3,773 \$604 \$377		\$26,479 \$4,237 \$2,648		\$30,252 \$4,840 \$3,025							
COST SUB - TOTAL						\$4,754		\$33,364 \$38,118									
CONTINGENCY		20.0%				\$951		\$6,673 \$7,624									
SUBTOTAL						\$5,705		\$40,036 \$45,742									
S&A		5.5%				\$314		\$2,202 \$2,516									
TOTAL THIS SHEET						\$6,019		\$42,238 \$48,257									

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: B5900E12

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER OPTIMIZATION

ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT
 

A. CONSTRUCTION COST	\$	45742.
B. SIOH	\$	2516.
C. DESIGN COST	\$	2745.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	45903.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	45903.

2. ENERGY SAVINGS (+) / COST (-)  
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	6157.	\$ 17978.	12.48	224371.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		6157.	\$ 17978.		\$ 224371.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-2745.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-25007.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-25007.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	74042.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ 15233.
5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 199364.
6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 4.34  
(IF < 1 PROJECT DOES NOT QUALIFY)
7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 3.01

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-9  
**SYSTEM MODIFICATION:** RENOVATE BOILER  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-9, renovate or replace existing boilers.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	172,255	172,255
ECO	--	--	165,014	165,014
Savings (Baseline-ECO)	0	0	7,241	7,241

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 7241 MMBtu/Yr X \$2.92 /MMBtu = \$21,144 per year  
 Total Energy Cost Savings: \$0 + \$21,144 = \$21,144 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$1,792 per year  
 Total: \$0 - \$1,792 = (\$1,792) per year

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total additional annual energy use due to operating chillers 3, 4, and 5  
more than necessary: 519,104 kWh/yr  
Total electrical consumption: 2,743,132 kWh/yr

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BOILER ECO-3

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	165014.
PEAK DAY GAS CONSUMP., 1000 CU FT	1616.
ELECTRICAL CONSUMPTION, KWH	2213589.
PEAK KW DEMAND (15 MIN BASIS)	1874.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2213589.
ON-PEAK KW DEMAND (15 MIN BASIS)	1874.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	101
CHILLER 6	0
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3311
BOILER 4	2349
BOILER 5	1613
BOILER 6	795
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.



LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: B5900EC3  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER RENOVATION  
 ANALYSIS DATE: 04-09-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	12023.
B. SIOH	\$	662.
C. DESIGN COST	\$	722.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	12066.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	12066.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	7241.	\$ 21144.	12.48	263874.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		7241.	\$ 21144.		\$ 263874.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -16325.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -16325.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 87078.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 19352.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 247549.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 20.52  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 .62

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 10  
**SYSTEM MODIFICATION:** OXYGEN TRIM FOR BURNERS  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-10, install oxygen trim for burners.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	172,255	172,255
ECO	--	--	169,073	169,073
Savings (Baseline-ECO)	0	0	3,182	3,182

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 3182 MMBtu/Yr X \$2.92 /MMBtu = \$9,291 per year  
**Total Energy Cost Savings: \$0 + \$9,291 = \$9,291 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$4,247 per year  
**Total: \$0 - \$4,247 = (\$4,247) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total additional annual energy use due to operating chillers 3, 4, and 5  
more than necessary: 519,104 kWh/yr  
Total electrical consumption: 2,743,132 kWh/yr

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BOILER ECO-4

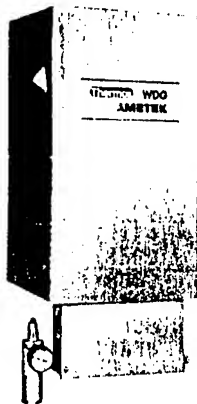
\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	168871.
PEAK DAY GAS CONSUMP., 1000 CU FT	1636.
ELECTRICAL CONSUMPTION, KWH	2213589.
PEAK KW DEMAND (15 MIN BASIS)	1874.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2213589.
ON-PEAK KW DEMAND (15 MIN BASIS)	1874.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	101
CHILLER 6	0
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3407
BOILER 4	2392
BOILER 5	1660
BOILER 6	851
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# SPECIFICATIONS - AIR-MIZER II SYSTEM

## SENSOR



**Nominal Dimensions:** 14 1/2" H x 10 1/2" W x 10" D (37.2 x 26 x 25.4 cm)

**Enclosure:** Weather resistant—S.S. case, nickel plated carbon steel base

**Weight:** 55 pounds (25 kg)

**Accuracy:**  $\pm 1\%$  of net excess oxygen

**Repeatability:**  $\pm 0.2\%$  of measured value

**Response:** 90% of full scale in less than 5 seconds

**Drift:** Less than 0.1% of sensor cell output per month

**Ambient Temperatures:** -5 to +175°F (-20.5 to +79°C)

**Sample Temperatures:** Up to 1300°F (704°C) with standard probe

**Sample Flow Rate:** 0.1 to 120 scfh (0.47 to 56.65 liters/minute)

**Air Aspirator Requirements:** 10 to 20 scfh (4.72 to 14.16 liters/min) at 15-100 psi (1.05 to 7.037 kg/cm<sup>2</sup>) (Aspirator air regulator furnished with sensor normally set at 2-7 psi; 0.14 - 0.49 kg/cm<sup>2</sup>)

**Calibration:** With analyzed oxygen in nitrogen sample. Calibration port provided.

## CONTROL UNIT

**Nominal Dimensions:** 12 1/2" H x 10 1/2" W x 9 1/2" D (32.1 x 27.6 x 23.2 cm)

**Enclosure:** Wall/panel mounted—meets the requirements for NEMA 4 areas

**Weight:** 22 pounds (10 kg)

**Temperature Control:** On-Off by microprocessor ( $\pm 1^\circ\text{C}$ )

**Linearization:** 256 segments from 20% to 0.2% O<sub>2</sub>, (218 from 10% to 0.2%), by microprocessor

**Controller Action:** On-Off—"On" time adjustable 2-20 seconds. "Off" time adjustable 2-60 seconds.

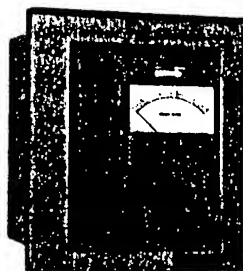
Deadband:  $\pm 0.25\%$  oxygen.

LED's indicate motor driving.

Will not allow decrease in air when O<sub>2</sub> is below 0.5% oxygen.

Air flow will increase to +15% max. if O<sub>2</sub> level is above 12%.

**Setpoint:** 0 to 10% oxygen by either of: A. Two banks of 5 slide pots, (Dual Fuel) selectable by slide switch; proper pot or pots connected to processor by switch in actuator. B. Manual pot on panel A or B selected by Remote/Local switch on panel. Setpoint indicated by edge reading meter (0-10%)



**Manual Control:** Manual/Auto switch and increase—decrease push buttons (Spring return switch inside control unit can override all control actions in the event of processor failure).

**Ready Indicator:** On at temperature set point. Off below temperature set point. Flashes above temperature set point. O<sub>2</sub> Control in "manual" when below set point.

**Oxygen Scale:** 20.9 to 0.1% O<sub>2</sub>, Logarithmic

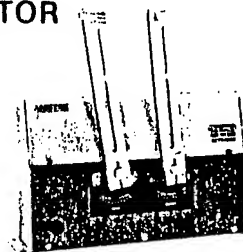
**Alarms:** High and Low O<sub>2</sub> adjustable 0.2 to 20%. RTD Failure (shuts down temperature control, and puts O<sub>2</sub> control in "manual").

**Increase Air Override:** Contact closure from optional combustibles or smoke detector alarm will cause Increase in air signal on each control pulse regardless of O<sub>2</sub> vs. O<sub>2</sub> setpoint relationship. Once combustibles contact opens, normal control will resume. This maintains air flow at a level where maximum allowable combustibles or smoke is not exceeded.

**Ambient Temperature Limits:** 32°F to 140°F (0 to +60°C)

**Recorder Output:** 0-100 mv = 0-20% O<sub>2</sub> Linear (0-50 mv = 0-10%) Other current or voltages outputs optional

## ACTUATOR



**Overall Size:** 17 1/2" L x 4" W x 10 1/4" H (44.5 x 10.2 x 26 cm)

**Weight:** 16.5 pounds (7.5 kg)

**Angular Travel (Input Arm):** 60°

**Linear Link Travel:** Adjustable 4" to 10" at 4" to 10" Radius (10.2 to 25.4 cm at 10.2 to 25.4 cm Radius)

**Linear Link Force:** 100 pounds at 4" Radius (45.5 kg at 10.2 cm Radius)

70 pounds at 6" Radius (31.8 kg at 15.2 cm Radius)

40 pounds at 10" Radius (18.2 kg at 25.4 cm Radius)

**Case:** Suitable for areas requiring NEMA 2 equipment (Drip proof indoor)

**Correction:** -15% to +15% (.85 to 1.15 gain) of normal air flow

**Speed:** 60 seconds from -15% to +15% correction (max.)

**Load Indication:** 9 position shorting switch tied to input arm

**Brake:** Internal brake will hold load at any above rated force without "coasting"

**Ambient Temperature Limits:** 0°F to 160°F (-18 to +71°C)

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: 5900EC10  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      LCCID 1.035  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS      REGION NOS. 6 CENSUS: 3  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER O2 TRIM CONTROL  
 ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	41716.
B. SIOH	\$	2295.
C. DESIGN COST	\$	2503.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	41863.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	41863.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	3182.	\$ 9291.	12.48	115957.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		3182.	\$ 9291.		\$ 115957.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -38690.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -38690.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 38266.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ 5044.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 77267.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.85  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 8.30

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 12  
**SYSTEM MODIFICATION:** STACK ECONOMIZERS  
**SYSTEMS TO MODIFY:** BOILER 1 THROUGH 6

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-12, install stack economizer for boilers.

The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	172,255	172,255
ECO	--	--	165,866	165,866
Savings (Baseline--ECO)	0	0	6,389	6,389

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 6389 MMBtu/Yr X \$2.92 /MMBtu = \$18,656 per year  
**Total Energy Cost Savings: \$0 + \$18,656 = \$18,656 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$0 - \$0 = \$0 per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total additional annual energy use due to operating chillers 3, 4, and 5  
more than necessary: 519,104 kWh/yr  
Total electrical consumption: 2,743,132 kWh/yr

PC-CUBE VERSION 2.0.3

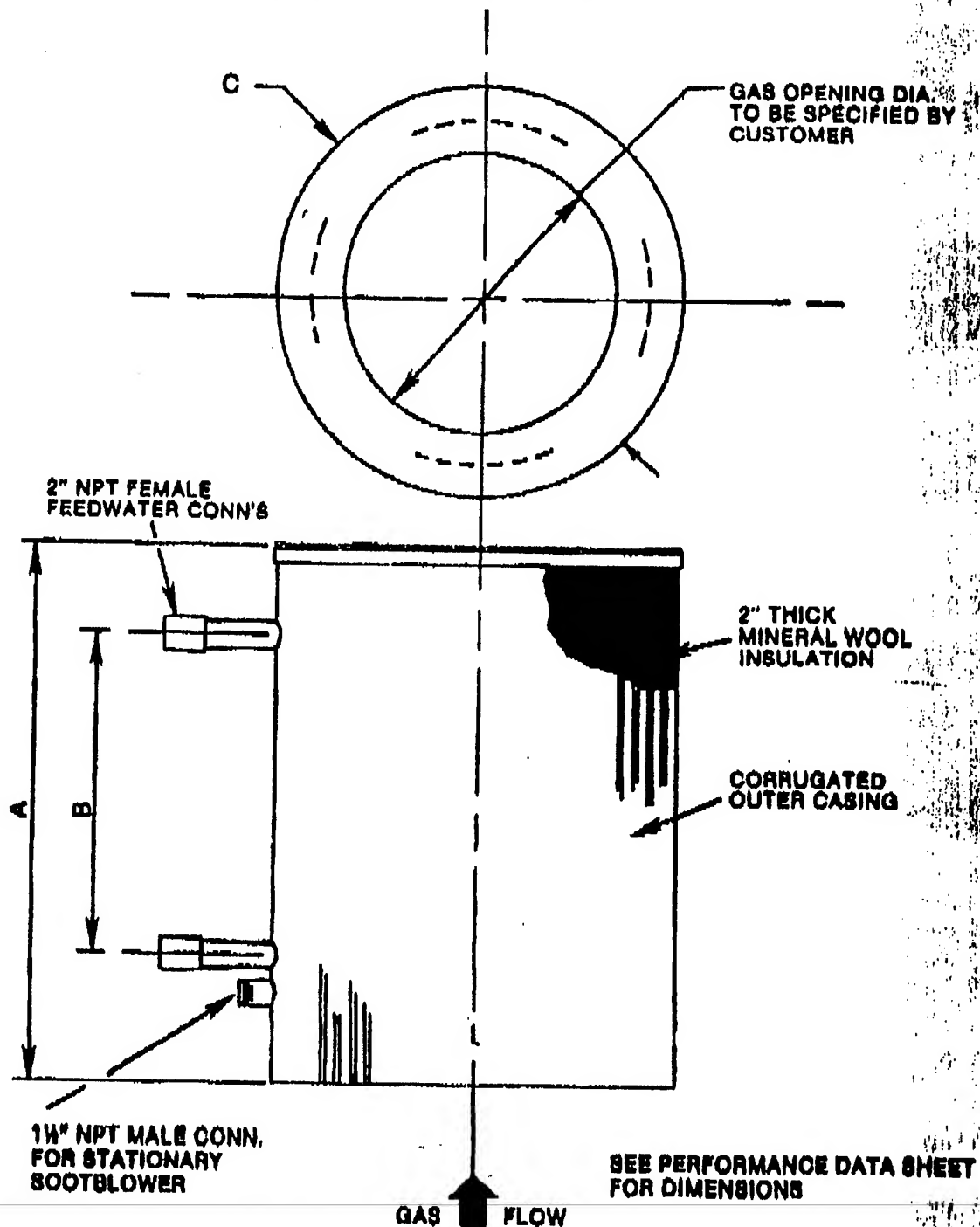
CENTRAL PLANT 5900 BOILER ECO-6

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	165866.
PEAK DAY GAS CONSUMP., 1000 CU FT	1617.
ELECTRICAL CONSUMPTION, KWH	2213589.
PEAK KW DEMAND (15 MIN BASIS)	1874.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2213589.
ON-PEAK KW DEMAND (15 MIN BASIS)	1874.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	101
CHILLER 6	0
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3311
BOILER 4	2368
BOILER 5	1649
BOILER 6	795
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# Kentube cylindrical FUEL ECONOMIZER



**Kentube**

4150 South Elwood • Tulsa, Oklahoma 47107  
918/446-4561 • Telex: 49-2353

GFV

\*\*\*UN\*\*\*  
CUSTOMER  
EMC Engineers  
PROPOSAL 318-10351-0-0  
RUN 00

KENTUBE  
4180 S. ELWOOD  
TULSA, OKLAHOMA

PRINTED 04/10/91  
TIME 09 HRS 10 MINS  
CUST. REFERENCE

CYLINDRICAL FUEL ECONOMIZER

MODEL 100930

OVERALL PERFORMANCE

COUNTER CURRENT FLOW

FLUID CIRCULATED IN TUBES IS WATER  
HEAT EXCHANGED 97907. BTU/HR  
U EXTERNAL 4.011 BTU/HR-SQFT-F  
LMTD 150.1 DEG F

PERFORMANCE SPECIFICATIONS

	TUBE SIDE ↓	GAS SIDE ↑	
FLOW RATE	2070.	2474.	LB/HR
TEMP IN	180.0	450.0	DEG F
TEMP OUT	227.2	301.1	DEG F
PRES IN	150.0 PSIG	14.7	PSIA
PRES DROP	.0 PSI	.19	IN WATER

OVERALL CONSTRUCTION

VERTICAL GAS FLOW

DIMENSIONS  
DIM A (HEIGHT) 3'-3/4"  
DIM B (NOZ C-C) 3'-3 3/8"  
DIM C (DIAMETER) 2'-1 1/2"  
DRAWING NO V-1  
BOOT BLOWERS ARE BUILT IN  
NOZZLE SIZE 2.0 IN  
SURFACE AREA 134. SQFT  
LIQUID WEIGHT 70. LB  
UNIT WEIGHT (DRY) 742. LB

CONSTRUCTION SPECIFICATIONS

	TUBE SIDE	
DESIGN PRESSURE	490.	PSI
TEST PRESSURE	735.	PSI
DESIGN TEMPERATURE	700.	DEG
TUBE OUTSIDE DIA	2.000	IN
MATERIAL	C/STL	
FIN THICKNESS	.060	IN
PITCH	3.00	FINS/
MATERIAL	C/STL	
INSULATION		
MATERIAL	MINERAL WOOL	
THICKNESS	2.0	IN



4150 S. Elwood  
Tulsa, Oklahoma 74107  
Phone: (918) 446-4561  
FAX: (918) 446-6340

# QUOTATION

T O	<b>EMC Engineers</b> 2750 South Wadsworth Blvd. Denver, CO 80227  Attention: Mr. Dennis Jones	QUOTATION DATE	YOUR REFERENCE		OUR REFERENCE
		04/10/91			318-10351-0-0
		SHIPPING ESTIMATE	TERMS		PAGE 1 OF 1
		8 Weeks*	Net 30 Days		
		SHIPPING DESTINATION	P.O.B. Kentube Shop**		

THANK YOU FOR YOUR INQUIRY. WE APPRECIATE THE OPPORTUNITY TO PROPOSE THE FOLLOWING:

ITEM	QUANTITY	DESCRIPTION	UNIT AMOUNT	AMOUNT
	4	<p>Kentube RETROMISER Fuel Economizer Cylindrical Model 100930, in accordance with the attached performance specifications.</p> <p><b>DESIGN FEATURES</b></p> <p>Finned tube unit; 3 Fins per inch; Vertical gas flow; Counter-current flow Fuel type: NATURAL GAS.</p> <p>Estimated Shipping Weight - 742. LBS.</p> <p>Pressure parts to Section I of the ASME Boiler &amp; Pressure Vessel Code.</p> <p>External 2" insulation with weatherproof, corrugated casing is included.</p> <p>Threaded drain and vent connections included.</p> <p>Kentube manually operated sootblower, integral with unit, included. Requires 85 psig to 250 psig supply pressure.</p>	\$ 12044.	

## ENCLOSURES

cc: Ted D. Miller Associates

NOTE: All shipping estimates are based on "after receipt of order" and "after final print approval" as required. Shipments can often be improved upon request. Please contact Kentube. Prices firm for 30 days and subject to change thereafter. No provision is made for Federal, State or Municipal taxes. All orders are subject to acceptance or rejection by the Credit Department of Kentube and to the Terms of Sale attached.

## YOUR REPRESENTATIVE IS:

✓ Ted D. Miller Associates  
2140 South Ivanhoe  
Denver, CO 80222

## YOUR ORDER WILL RECEIVE OUR PROMPT ATTENTION

KENTUBE FABRICATED PRODUCTS

*Larry Wolfenbarger*  
Larry Wolfenbarger  
Product Sales Engineer



# QUOTATION

TO	EMC Engineers	/318-10351-0-0
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PAGE	2	OF	2
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ITEM	QUANTITY	DESCRIPTION	UNIT AMOUNT	AMOUNT
<b>SUGGESTED ACCESSORIES</b> (Quantities below are for each unit)				
1		Bolted access manway in casing, approximately 16" Square, carbon steel construction.	\$ 300.	\$ 300.
1		1/2" Threaded connection for safety relief valve on header.	\$ 100.	\$ 100.
1		1/2" Threaded safety relief valve, Kunkle series 927.	\$ 500.	\$ 500.
** All prepaid and bill shipments will be at the billable freight amount plus a service charge of 10%. A service charge is not required for collect shipments or third party billing.				
***** * KENTUBE is a member of the * * AMERICAN BOILER MANUFACTURERS ASSOCIATION * *****				



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5900EC11

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ECONOMIZER AIR PREHEAT

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$ 133077.
B. SIOH	\$ 7320.
C. DESIGN COST	\$ 7985.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$ 133544.
E. SALVAGE VALUE COST	-\$ 0.
F. TOTAL INVESTMENT (1D-1E)	\$ 133544.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	6389.	\$ 18656.	17.52	326851.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		6389.	\$ 18656.		\$ 326851.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      11.65

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 107861.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F) = \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ 18656.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 326851.

6. DISCOUNTED SAVINGS RATIO      (SIR)=(5 / 1F)= 2.45

(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)      SPB=1F/4      7.16

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 5900  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-13  
**SYSTEM MODIFICATION:** VARIABLE SPEED PUMPING  
**SYSTEMS TO MODIFY:** CENTRAL PLANT

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs and spread sheet are compared to determine the energy savings for ECO-13, install variable speed pumping.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	2,224,000	--	7,591
ECO	--	2,021,000	--	6,898
Savings (Baseline-ECO)	0	203,000	0	693

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 692.839 MMBtu/Yr X \$4.0141 /MMBtu = \$2,781 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$2,781 + \$0 = \$2,781 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$2,507 per year  
**Total: \$0 - \$2,507 = (\$2,507) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 BASELINE

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	2224028.
PEAK KW DEMAND (15 MIN BASIS)	1886.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	2224028.
ON-PEAK KW DEMAND (15 MIN BASIS)	1886.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total additional annual energy use due to operating chillers 3, 4, and 5  
more than necessary: 519,104 kWh/yr  
Total electrical consumption: 2,743,132 kWh/yr

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 5900 ECO C7- VARIABLE SPEED PUMPING

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	172256.
PEAK DAY GAS CONSUMP., 1000 CU FT	1663.
ELECTRICAL CONSUMPTION, KWH	1970638.
PEAK KW DEMAND (15 MIN BASIS)	1694.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	1970638.
ON-PEAK KW DEMAND (15 MIN BASIS)	1694.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	2215
CHILLER 3	810
CHILLER 4	419
CHILLER 5	84
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	3624
BOILER 3	3443
BOILER 4	2445
BOILER 5	1720
BOILER 6	910
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

Total electrical consumption = PC-CUBE est. 1,970,638 kWh  
 Spead sheet est. 50,616 kWh  
 Total 2,021,254 kWh

# VARIABLE PUMPING ESTIMATE

PERCENT LOAD	GPM @ PERCENT LOAD	PART LOAD HRS	PRESSURE FT.HD.	BHP	HP	kW	kWh
10	369	496	1.6	0.19	0.21	0.15	77
20	738	961	6.4	1.49	1.66	1.24	1188
30	1107	1184	14.4	5.03	5.59	4.17	4938
40	1476	221	25.6	11.93	13.25	9.89	2185
50	1845	116	40	23.30	25.88	19.31	2240
60	2214	275	57.6	40.25	44.73	33.37	9176
70	2583	298	78.4	63.92	71.03	52.98	15789
80	2952	37	102.4	95.42	106.02	79.09	2926
90	3321	21	129.6	135.86	150.95	112.61	2365
100	3690	63	160	186.36	207.07	154.47	9732
		3672					50616

1. MAXIMUM (100%) GPM FIXED AT CURRENT FLOW RATE, 3690 GPM
2. PART LOAD HRS FROM CHILLER BASE LOAD RUN FOR INSTRUMENTATION ECO
3. MAXIMUM PRESSURE FT.HD FOR PUMPING, ESTIMATE 160 FT.HD.  
NEW PRESSURE = OLD PRESSURE TIME THE RATIO OF THE SQUARE OF THE FLOWS
4. BHP EQUAL TO GPM TIME HEAD DIVID BY 3960 AND 80% EFFICIENCY
5. HP EQUAL TO BHP DIVIDED BY 90% EFFICIENCY
6. kW EQUAL TO HP TIMES .746 kW per HP
7. kWh EQUAL TO kW TIMES HOURS

# **COST ESTIMATE ANALYSIS**

INVOITATION NO./CONTRACT NO.										EFFECTIVE PRICING		DATE PREPARED	
DACA 59-90-C-0087										DATE APR. 91		11-Apr-91	
CODE A <input type="checkbox"/> CODE B <input type="checkbox"/> CODE C <input type="checkbox"/>										DRAWING NO.		SHT OF	
OTHER <input type="checkbox"/>										ESTIMATOR		CHECKED BY	
										D.J.		SHIPPING	
CHILLER ECO-4 BLDG. 5900										TOTAL		Unit	
VARIABLE SPEED PUMPING												Wt	
TASK DESCRIPTION										Cost		Total	
PUMP - 900 GPM @ 30 TDH													
PUMP - 1260 GPM @ 160 TDH													
PIPE - 8"													
PIPE - 6"													
ELL - 8"													
ELL - 6"													
TEE - 8"													
TEE - 6"													
PIPE INSULATION - 8"X1.5", FG/ASJ													
PIPE INSULATION - 6"X1.5", FG/ASJ													
MOTOR CONTROL CENTER													
10 HP FUNR (1X)													
100 HP FUNR (3X)													
100 HP VARIABLE SPEED DRIVE (3X)													
600 AMP CIRCUIT BREAKER (5X)													
INCOMING LINE SECTION													
10 HP MOTOR CIRCUIT WIRING													
100 HP MOTOR CIRCUIT WIRING													
FEEDER 4#350, 3" CONDUIT													
CONTROL WIRING 9#12													
CONTROLS													
CHWP ST/SP													
DP (LIQUID) PUMP STATUS													
INSERT. FLOW METER													
AI FORM EMCS													
SUBTOTAL													
OVERHEAD, BOND													
PROFIT													
COST SUB - TOTAL													
CONTINGENCY													
SUBTOTAL													
S&A													
TOTAL THIS SHEET													

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 5900EC13

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: VARIABLE SPEED PUMPING

ANALYSIS DATE: 04-15-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	149733.
B. SIOH	\$	8236.
C. DESIGN COST	\$	8984.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	150258.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	150258.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	693.	\$ 2782.	11.37	31628.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		693.	\$ 2782.		\$ 31628.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-2507.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-29207.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-29207.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	10437.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 275.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 2421.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .02  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 546.98

**CENTRAL PLANT 6003**

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 1  
**SYSTEM MODIFICATION:** ADD INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:** CHILLER PLANT

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-1, install instrumentation to facilitate efficient operation of chiller plant. The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	977,000	71,623	74,958
ECO	--	762,000	71,623	74,224
Savings (Baseline-ECO)	0	215,000	0	734

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 734 MMBtu/Yr X \$4.0141 /MMBtu = \$2,946 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$2,946 + \$0 = \$2,946 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$320 per year  
**Total: \$0 - \$320 = (\$320)per year**

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 6003 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	71623.
PEAK DAY GAS CONSUMP., 1000 CU FT	703.
ELECTRICAL CONSUMPTION, KWH	976518.
PEAK KW DEMAND (15 MIN BASIS)	417.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	976518.
ON-PEAK KW DEMAND (15 MIN BASIS)	417.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2615
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

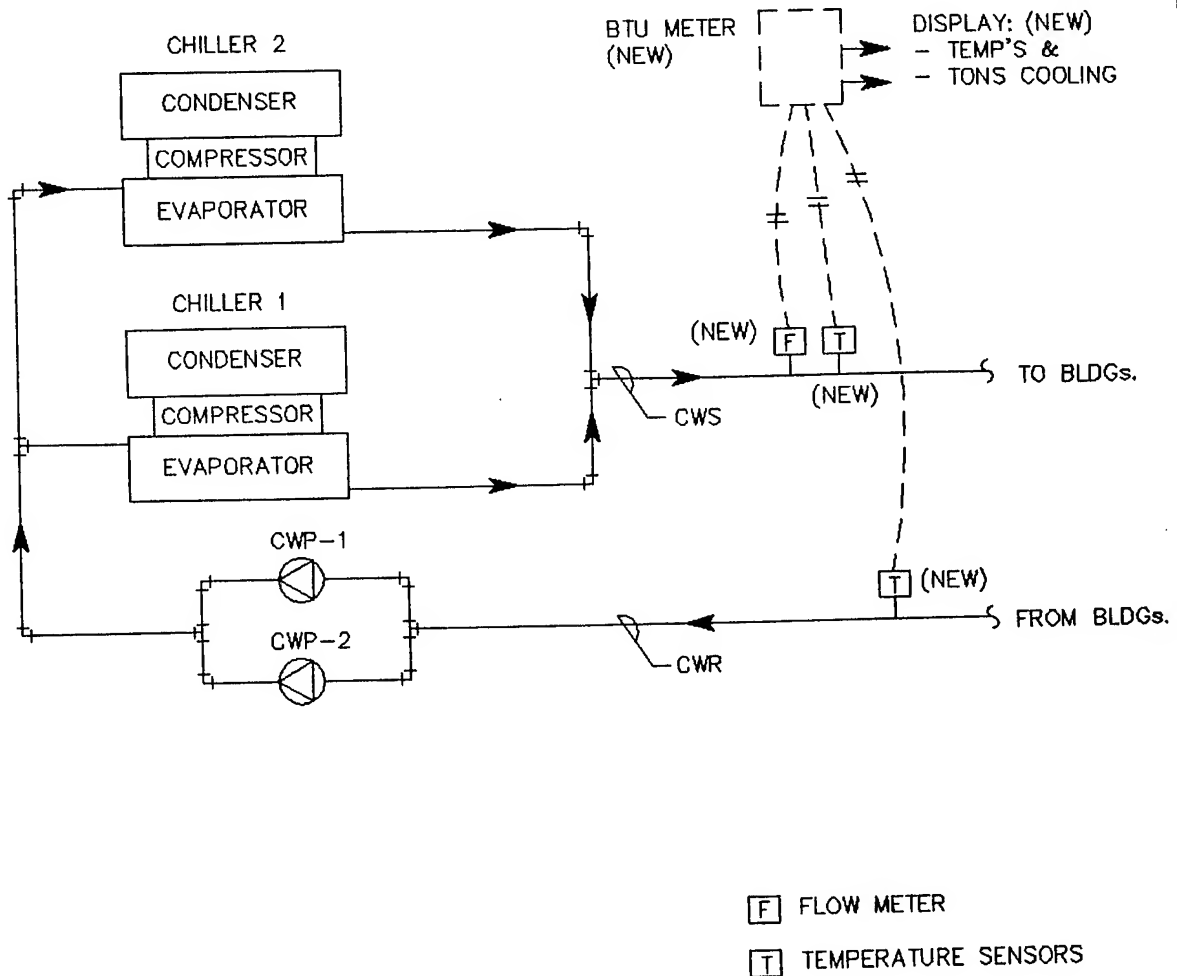
## CENTRAL PLANT 6003 CHILLER ECO-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	71623.
PEAK DAY GAS CONSUMP., 1000 CU FT	703.
ELECTRICAL CONSUMPTION, KWH	761852.
PEAK KW DEMAND (15 MIN BASIS)	445.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	761852.
ON-PEAK KW DEMAND (15 MIN BASIS)	445.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	288
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2615
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# ECO-1, INSTRUMENTATION FOR CHILLER PLANT (TYPICAL)



[C-ECO-1.DWG]

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: C6003ECO

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: CHILLER INSTRUMENTATION

ANALYSIS DATE: 04-08-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT
 

A. CONSTRUCTION COST	\$	5327.
B. SIOH	\$	293.
C. DESIGN COST	\$	320.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	5346.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	5346.
  
2. ENERGY SAVINGS (+) / COST (-)  
 ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS
 

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	734.	\$ 2946.	8.78	25868.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	0.	\$ 0.	12.48	0.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		734.	\$ 2946.		\$ 25868.
  
3. NON ENERGY SAVINGS(+) / COST(-)
 

A. ANNUAL RECURRING (+/-)	\$	280.
(1) DISCOUNT FACTOR (TABLE A)		9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	2551.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	2551.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	8537.
A IF 3D1 IS = OR > 3C GO TO ITEM 4 B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= _____ C IF 3D1B IS = > 1 GO TO ITEM 4 D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		
  
4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 3226.
5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 28419.
6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 5.32  
 (IF < 1 PROJECT DOES NOT QUALIFY)
7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 1.66

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-4  
**SYSTEM MODIFICATION:** INSTALL ICE STORAGE COOLING SYSTEM  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Hand calculation sheet was prepared to determine the energy savings for ECO-4, install ice storage system for HVAC cooling.  
 It was estimated that the peak electrical demand can be saved by installing ice storage cooling system.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	544	0	0	0

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$0 + \$0 = \$0 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 544 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$11,666 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$11,666 - \$0 = \$11,666 per year**

[ECO-SHT.WK3]

# A new application of an old idea that can cut air conditioning energy costs in half.

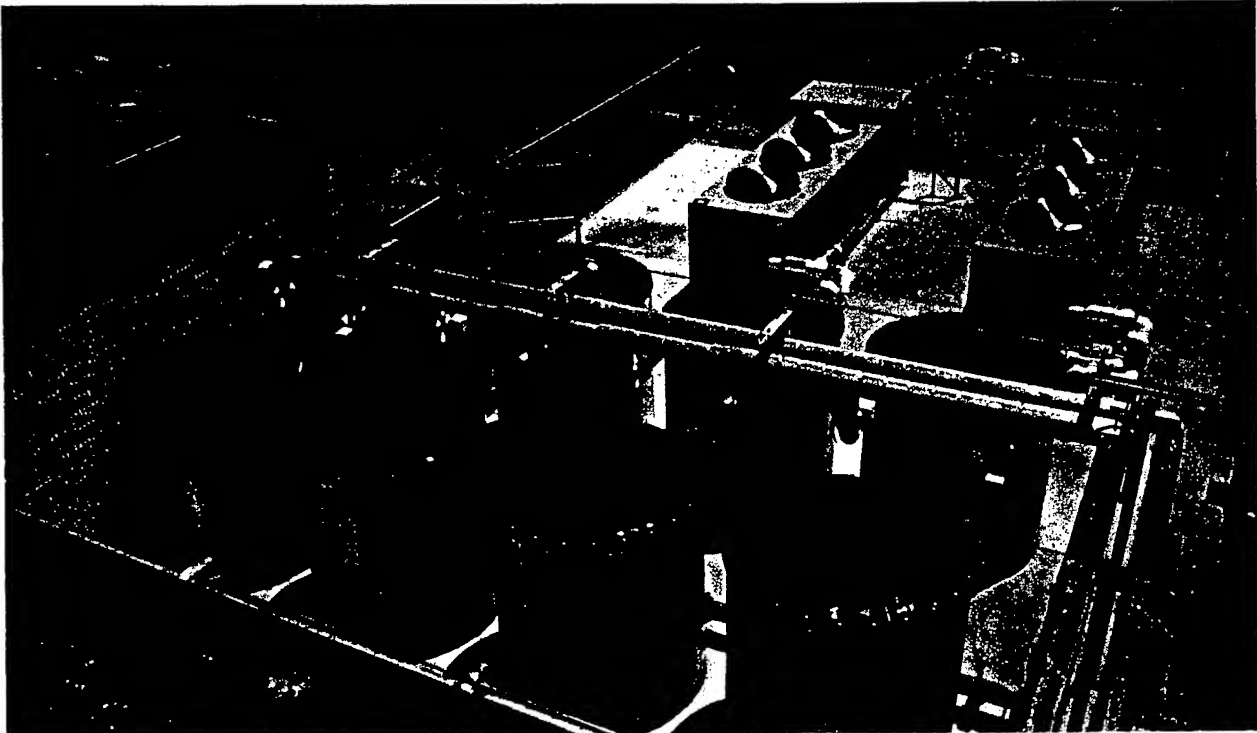
Air conditioning during summer daytime hours is the largest single contributor to utility "peak demand" charges. After noon, as more air conditioners are needed to maintain comfortable temperatures, the increased demand for electricity adds to that already created by lighting, operating equipment, computers and thousands of other uses. This requires the utility to bring additional, more costly generating sources on line to handle its increased demand. Commercial users whose large air conditioning loads contribute to these added generating requirements are assessed an additional charge based on their highest on-peak demand for electricity.

An Ice Bank Stored Cooling System is either a load-shifting or load-leveling method which will significantly lower demand charges during the air conditioning season and, consequently, energy costs. It uses a standard packaged chiller to produce solid ice at night during off-peak periods when the building's electrical needs are at a minimum. The ice is built and stored in modular ice tanks to provide cooling to help meet the building's air conditioning load requirement the following day.

Making ice at night and using its stored energy during the day is not a new or experimental idea. This concept had been employed for years in cooling short-peak applications such as churches and theatres. However, longer peak uses were served by air-source rooftop and chiller-type air conditioners which were less costly to install. Now there is renewed interest in a broad use of ice-making systems by both users and utilities as the best way to offset rising operating costs. In fact, Stored Cooling Systems are what summer-peaking utilities *must have* to avoid the unbearable costs of new generating plants.

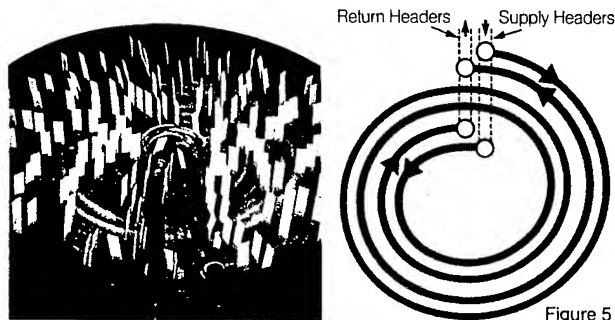
Ice Banks not only can cut operating costs in half but they can also substantially reduce capital outlays when systems are suitably designed for new commercial and industrial buildings. Engineers can specify half-size chillers operating 24 hours a day rather than full-size chillers operating only 10 or 12 hours per day. In retrofit applications, an Ice Bank Stored Cooling System can often provide cooling for an addition to a building without adding chiller capacity.

Atlantic Southern Properties Mays Landing NJ



# How the LEVLOAD System Works

The LEVLOAD Ice Bank is a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. They are available in four sizes - 90, 100, 190 and 570 ton-hours. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the patented temperature-averaging effect of closely spaced counterflow heat exchanger tubes, Figure 5. Water does not become surrounded by ice during the freezing process and can move freely as ice forms, preventing stress or damage to the tank.



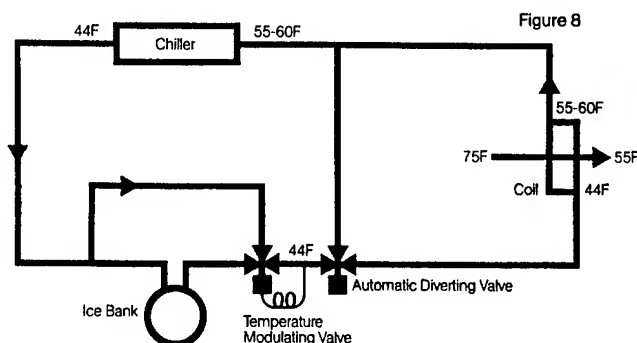
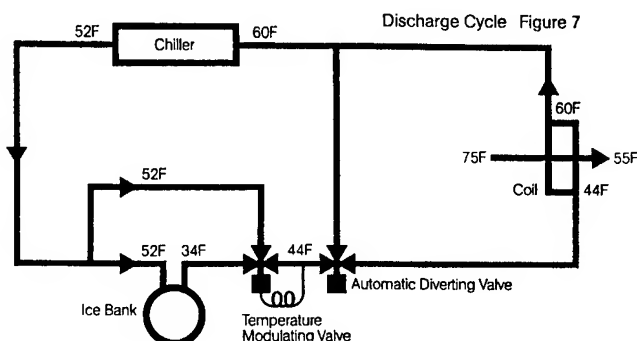
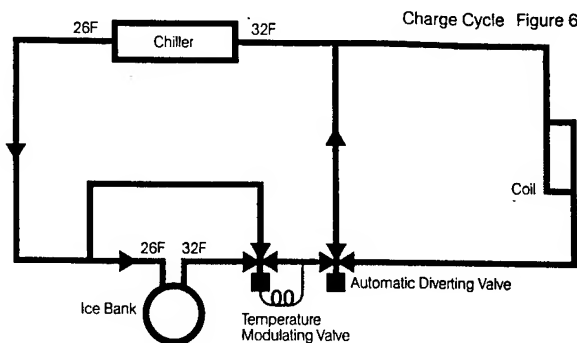
Typical flow diagrams for a Partial Storage System are shown in Figures 6 and 7.

At night, the water-glycol solution circulates through the chiller and the Ice Bank heat exchanger, bypassing the air handler coil. The fluid is at 26F and freezes the water surrounding the heat exchanger.

During the day, the solution is cooled by the Ice Bank from 52F to 34F. A temperature modulating valve set at 44F in a bypass loop around the Ice Bank permits a sufficient quantity of 52F fluid to bypass the Ice Bank, mix with the 34F fluid, and achieve the desired 44F temperature. The 44F fluid enters the coil, where it cools air from 75F to 55F. The fluid leaves the coil at 60F, enters the chiller and is cooled to 52F.

It should be noted that, while making ice at night, the chiller must cool the water-glycol solution to 26F, rather than produce 44 or 45F water temperatures required for conventional air conditioning systems. This has the effect of "derating" the nominal chiller capacity by approximately 30 percent. Compressor efficiency, however, is only slightly reduced because lower nighttime temperatures result in cooler condenser water from the cooling tower and help keep the unit operating efficiently. Similarly, air cooled chillers benefit from cooler condenser entering air temperatures at night.

The temperature modulating valve in the bypass loop has the added advantage of providing unlimited capacity control. During many mild temperature days in the spring and fall, the chiller will be capable of providing all the necessary cooling for the building without assistance from stored cooling. When the building's actual cooling load is equal to or lower than the chiller capacity, all of the system coolant flows through the bypass loop, as in Figure 8.



The glycol recommended for the solution is an ethylene glycol-based industrial coolant, such as Dow Chemical Company's Dowtherm® SR-1 or Union Carbide Corporation's UCARTHERM®, which are specially formulated for low viscosity and superior heat transfer properties. These contain a multi-component corrosion inhibitor system which is effective with most materials of construction, including aluminum, copper, solder and plastics. Unlike automotive-type anti-freeze, they produce no films and contain no anti-leak agents to interfere with heat transfer efficiency and permit use of standard system pumps, seals and air handler coils. However, because of the slight difference in heat transfer coefficient between water-glycol and plain water, coil capacity should be increased by approximately 5 percent. It is also important that the water and glycol be thoroughly mixed before the solution enters the system.

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 6003EC4

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: ICE STORAGE COOLING SYSTEM

ANALYSIS DATE: 04-18-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$ 204000.
B. SIOH	\$ 11220.
C. DESIGN COST	\$ 12240.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$ 204714.
E. SALVAGE VALUE COST	-\$ 0.
F. TOTAL INVESTMENT (1D-1E)	\$ 204714.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	11.37	0.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		0.	\$ 0.		\$ 0.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$ 11666.
(1) DISCOUNT FACTOR (TABLE A)	11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$ 135909.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$ 135909.
D. PROJECT NON ENERGY QUALIFICATION TEST	
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$ 0.
A IF 3D1 IS = OR > 3C GO TO ITEM 4	
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=	.00
C IF 3D1B IS = > 1 GO TO ITEM 4	
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY	

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 11666.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 135909.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .66  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 17.55

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(A)  
**SYSTEM MODIFICATION:** TWO SPEED FANS FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER (NORTH)

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	39,462	--	135
ECO	--	13,644	--	47
Savings (Baseline-ECO)	0	25,818	0	88

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 88 MMBtu/Yr X \$4.0141 /MMBtu = \$354 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$354 + \$0 = \$354 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$0 per year  
 Total: \$0 - \$0 = \$0 per year

[ECO-SHT.WK3]

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(A)  
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**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	39,462	--	135
ECO	--	13,644	--	47
Savings (Baseline-ECO)	0	25,818	0	88

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 88 MMBtu/Yr X \$4.0141 /MMBtu = \$354 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
 Total Energy Cost Savings: \$354 + \$0 = \$354 per year

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$0 per year  
 Total: \$0 - \$0 = \$0 per year

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input. The calculations take into account multi-cell towers (part 7). The control sequence is:

- 0-25% load, fan 1, half speed cycling.
- 25-50% load, fan 1 half speed running, fan 2 half speed cycling:
- 50-75% load, fan 1 full speed cycling, fan 2 half speed running.
- 75-100% load, fan 1 full speed running, fan 2 full speed cycling.

kWh per bin, for % design loads less than 25% load = (fan 1 power kW) \* 14% \* (% design load / 25) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 25% to 50% load = (fan 1 power kW \* 14% \* 4 hours per bin \* days per month) \* ( fan 2 power kW \* 14% \* ((% design load - 25) / 25) \* 4 hours per bin \* days per month )

kWh per bin, for % design loads 50% to 75% load = (fan 2 power kW \* 14% \* 4 hours per bin \* days per month) \* ( fan 1 power kW \* ((% design load - 50) / 25) \* 4 hours per bin \* days per month )

kWh per bin, for % design loads 75% to 100% load = ( fan 1 power kW \* 4 hours per bin \* days per month ) + ( fan 2 power kW \* ((% design load - 75) / 25) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

<b>CENTRAL PLANT</b>		<b>6003</b>
<b>DESIGN CONDITIONS</b>		
– WBT (DB, DEG F)		78
– WATER FLOW (gpm)		2260
– CNWR (DEG F)		95
– CNWS (DEG F)		85
<b>ASSUMPTION LIQUID TO GAS RATIO</b>		<b>2</b>
– AIR FLOW (LBS/MIN)		9379
<b>HEAT REJECTION CAPACITY (Btu/min)</b>		<b>187580</b>
<b>DELTA ENTHALPY (Btu/lb)</b>		<b>20</b>
<b>DESIGN ENTHALPY (Btu/lb)</b>		<b>41.58</b>
<b>TOTAL ENTHALPY</b>		<b>61.58</b>
<b>EXIT AIR WB (LOOK UP)</b>		<b>93.2</b>
<b>SPECIFIC VOLUME OF EXIT AIR (LOOK UP)</b>		<b>15.1</b>
<b>100% DESIGN CFM @ WB</b>		<b>141623</b>
<b>MOTOR DATA</b>		
– FAN 1 POWER (kW)		36.3
– FAN 2 POWER (kW)		0
– FAN 3 POWER (kW)		0
– FAN 4 POWER (kW)		0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET – BULB AVERAGES (4 hour bins)						DESIGN
	1–4	5–8	9–12	13–16	17–20	21–24	WB
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	78
MAY	57.1	56.6	61.2	63.9	63	59.4	78
JUNE	66.8	66.6	69.9	71	70.5	68.2	78
JULY	70.8	70.9	74.5	76	74.9	72.6	78
AUGUST	66.9	67	71	72	71	68.5	78
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	78
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	78

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	41.58
MAY	24.53	24.21	27.28	29.23	28.57	26.06	41.58
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	41.58
JULY	34.77	34.86	38.14	39.57	38.52	36.37	41.58
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	41.58
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	41.58
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	41.58

COOLING PROFILE OF CENTRAL PLANTS							PEAK LOAD
	1-4	5-8	9-12	13-16	17-20	21-24	(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.7	0.7	0.3	0.3	7151000
JUNE	0.3	0.3	0.7	0.7	0.3	0.3	9058000
JULY	0.3	0.3	0.7	0.7	0.3	0.3	9058000
AUGUST	0.3	0.3	0.7	0.7	0.3	0.3	9058000
SEPTEMBER	0.3	0.3	0.7	0.7	0.3	0.3	9058000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.9	1.9	1.7	1.6	1.7	1.8	31
JUNE	1.5	1.5	1.4	1.3	1.4	1.4	30
JULY	1.3	1.3	1.2	1.1	1.2	1.3	31
AUGUST	1.5	1.5	1.3	1.3	1.3	1.4	31
SEPTEMBER	1.6	1.6	1.5	1.4	1.5	1.6	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

	% DESIGN LOAD						DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	12.8	12.7	32.2	34.2	14.3	13.3	31
JUNE	19.9	19.8	50.8	52.6	22.2	20.7	30
JULY	22.4	22.5	59.7	63.6	26.0	23.8	31
AUGUST	20.0	20.0	52.6	54.4	22.5	20.9	31
SEPTEMBER	19.1	19.0	47.7	49.1	20.2	19.3	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

	SINGLE SPEED CONTROL (kWh)						TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kW)
APRIL	0	0	0	0	0	0	
MAY	575	571	1450	1538	646	600	
JUNE	868	863	2212	2290	965	902	
JULY	1007	1011	2688	2863	1171	1071	
AUGUST	899	901	2366	2447	1014	940	
SEPTEMBER	831	827	2079	2141	881	841	
OCTOBER	0	0	0	0	0	0	
TOTAL	4181	4173	10796	11279	4678	4354	39462

	TWO SPEED CONTROL (kWh)						TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	161	160	406	431	181	168	
JUNE	243	242	678	834	270	252	
JULY	282	283	1506	1855	328	300	
AUGUST	252	252	862	1023	284	263	
SEPTEMBER	233	232	582	599	247	236	
OCTOBER	0	0	0	0	0	0	
TOTAL	1171	1169	4034	4743	1310	1219	13644

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PROJECT ENERGY SURVEY OF ARMY BOILER AND CHILLER

LOCATION FT. SILL, OKLAHOMA

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 6003EC5A

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	10428.
B. SIOH	\$	574.
C. DESIGN COST	\$	626.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	10465.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	10465.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	88.	\$ 354.	11.37	4022.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		88.	\$ 354.		\$ 4022.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	0.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	0.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	0.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1327.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		_____
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 354.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 4022.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .38  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 29.59

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 5(B)  
**SYSTEM MODIFICATION:** VARIABLE SPEED DRIVE FOR COOLING TOWER  
**SYSTEMS TO MODIFY:** COOLING TOWER (NORTH)

**CALCULATION DESCRIPTION:**

Two spread sheets are compared to determine the energy savings for ECO-5, install two-speed (5A) or variable speed (5B) motors for cooling tower. The spread sheets is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The spread sheets is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the spread sheets represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	39,462	--	135
ECO	--	8,437	--	29
Savings (Baseline-ECO)	0	31,025	0	106

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 106 MMBtu/Yr X \$4.0141 /MMBtu = \$425 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$425 + \$0 = \$425 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$570 per year  
**Total: \$0 - \$570 = (\$570) per year**

[ECO-SHT.WK3]

Two-speed cooling tower and variable speed cooling tower calculation description:

1. The design conditions were taken from the original design documents, including wet bulb temperatures, condenser water flow, and condenser supply and return temperatures.
2. Based on an assumed liquid to gas ratio, the delta enthalpy was calculated for entering air versus leaving air conditions. The final total enthalpy of the leaving air was calculated based on the design entering air enthalpy plus the delta enthalpy.
3. The fan motor kW is based on field measurements.
4. The "WET BULB AVERAGES" are the wet bulb temperatures calculated for 4 hour bins, for each cooling month, from ASHRAE weather data for Oklahoma City, Oklahoma (part 1).
5. The "ENTHALPY FOR AVERAGE WET BULBS" are the enthalpy for each of the wet-bulb (part 1.), determined from look-up tables (part 2).
6. The "COOLING PROFILE OF CENTRAL PLANTS," is the average % load estimated for the chiller plant, for the time bins (part 3). Note there is 0% load for those hours when the chiller is assumed to be off.

The "PEAK LOAD" per month is the estimated peak hourly load (part 3, last column).

7. The "RATIO OF AVERAGE MONTHLY ENTHALPY TO DESIGN ENTHALPY" for time bins (part 4) =

(Total exit air design enthalpy minus average monthly enthalpy, part 2) / (entering air design enthalpy)

The "DAYS PER MONTH OPER." is the total days per month the cooling tower operates (part 4, last column).

8. The "% DESIGN LOAD" on tower for time bins (part 5) =

(% load on plant, part 3 \* monthly peak load, part 3) / ( Highest monthly peak load, part 3) \* ( 1 / ratio of monthly enthalpy, part 4)

9. For a single speed cooling tower fan the energy usage (kWh) is based on the idea that the tower fan cycle in direct proportion to the % design load on the tower, (part 6) =

kWh per bin = (total fan power kW) \* (% design load, part 5 \* 4 hours per bin \* days per month)

Total kWh = sum of all kWh bins

10. For a two-speed cooling tower fan the energy usage (kWh) is based on the premise that when a tower cell is at less than 50% of its design load, it operates at half speed. A fan running at half speed uses 14% of the maximum power input. The calculations take into account multi-cell towers (part 7). The control sequence is:

- 0-25% load, fan 1, half speed cycling.
- 25-50% load, fan 1 half speed running, fan 2 half speed cycling:
- 50-75% load, fan 1 full speed cycling, fan 2 half speed running.
- 75-100% load, fan 1 full speed running, fan 2 full speed cycling.

kWh per bin, for % design loads less than 25% load = (fan 1 power kW) \* 14% \* (% design load / 25) \* 4 hours per bin \* days per month.

kWh per bin, for % design loads 25% to 50% load = (fan 1 power kW \* 14% \* 4 hours per bin \* days per month) \* ( fan 2 power kW \* 14% \* ((% design load - 25) / 25) \* 4 hours per bin \* days per month )

kWh per bin, for % design loads 50% to 75% load = (fan 2 power kW \* 14% \* 4 hours per bin \* days per month) \* ( fan 1 power kW \* ((% design load - 50) / 25) \* 4 hours per bin \* days per month )

kWh per bin, for % design loads 75% to 100% load = ( fan 1 power kW \* 4 hours per bin \* days per month ) + ( fan 2 power kW \* ((% design load - 75) / 25) \* 4 hours per bin \* days per month )

kWh total = sum of all kWh bins

11. For a variable speed cooling tower fan the energy usage (kWh) is based on the premise that the tower fan percent air volume is directly proportional to the percent load on the cooling tower; and the fan energy is proportional to the cube of the air volume. The calculations take into account multi-cell towers (part 8):

kWh per bin, for 0 to 100% load = ( total fan power kW) \* ((% design load)<sup>3</sup> / 80% efficiency ) \* 4 hours per bin \* days per month.

kWh total = sum of all kWh bins

CENTRAL PLANT 6003	
DESIGN CONDITIONS	
– WBT (DB, DEG F)	78
– WATER FLOW (gpm)	2260
– CNWR (DEG F)	95
– CNWS (DEG F)	85
ASSUMPTION LIQUID TO GAS RATIO	
– AIR FLOW (LBS/MIN)	9379
HEAT REJECTION CAPACITY (Btu/min)	
DELTA ENTHALPY (Btu/lb)	20
DESIGN ENTHALPY (Btu/lb)	41.58
TOTAL ENTHALPY	61.58
EXIT AIR WB (LOOK UP)	93.2
SPECIFIC VOLUME OF EXIT AIR (LOOK UP)	15.1
100% DESIGN CFM @ WB	141623
MOTOR DATA	
– FAN 1 POWER (kW)	36.3
– FAN 2 POWER (kW)	0
– FAN 3 POWER (kW)	0
– FAN 4 POWER (kW)	0

ASHRAE WEATHER DATA – OKLAHOMA CITY, OKLAHOMA

	WET-BULB AVERAGES (4 hour bins)						DESIGN WB
	1–4	5–8	9–12	13–16	17–20	21–24	
APRIL	48.6	47.8	52.2	55.6	54.6	51.4	78
MAY	57.1	56.6	61.2	63.9	63	59.4	78
JUNE	66.8	66.6	69.9	71	70.5	68.2	78
JULY	70.8	70.9	74.5	76	74.9	72.6	78
AUGUST	66.9	67	71	72	71	68.5	78
SEPTEMBER	65.1	64.9	67.8	68.9	67.4	65.6	78
OCTOBER	51.2	50.4	55.1	57.5	55.2	52.5	78

ENTHALPY FOR AVERAGE WET-BULBS							DESIGN
	1-4	5-8	9-12	13-16	17-20	21-24	ENTHALPY
APRIL	19.64	19.11	21.55	23.58	22.98	21.09	41.58
MAY	24.53	24.21	27.28	29.23	28.57	26.06	41.58
JUNE	31.47	31.31	34.01	34.95	34.51	32.59	41.58
JULY	34.77	34.86	38.14	39.57	38.52	36.37	41.58
AUGUST	31.54	31.62	34.95	35.83	34.95	32.84	41.58
SEPTEMBER	30.13	29.98	32.25	33.09	31.93	30.52	41.58
OCTOBER	20.98	20.53	23.28	24.72	23.34	21.72	41.58

COOLING PROFILE OF CENTRAL PLANTS							PEAK
	1-4	5-8	9-12	13-16	17-20	21-24	LOAD
							(Btuh)
APRIL	0	0	0	0	0	0	0
MAY	0.3	0.3	0.7	0.7	0.3	0.3	7151000
JUNE	0.3	0.3	0.7	0.7	0.3	0.3	9058000
JULY	0.3	0.3	0.7	0.7	0.3	0.3	9058000
AUGUST	0.3	0.3	0.7	0.7	0.3	0.3	9058000
SEPTEMBER	0.3	0.3	0.7	0.7	0.3	0.3	9058000
OCTOBER	0	0	0	0	0	0	0

RATIO OF MONTHLY ENTHALPY TO DESIGN ENTHALPY							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	1.9	1.9	1.7	1.6	1.7	1.8	31
JUNE	1.5	1.5	1.4	1.3	1.4	1.4	30
JULY	1.3	1.3	1.2	1.1	1.2	1.3	31
AUGUST	1.5	1.5	1.3	1.3	1.3	1.4	31
SEPTEMBER	1.6	1.6	1.5	1.4	1.5	1.6	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

% DESIGN LOAD							DAYS PER
	1-4	5-8	9-12	13-16	17-20	21-24	MONTH OPER.
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	30
MAY	12.8	12.7	32.2	34.2	14.3	13.3	31
JUNE	19.9	19.8	50.8	52.6	22.2	20.7	30
JULY	22.4	22.5	59.7	63.6	26.0	23.8	31
AUGUST	20.0	20.0	52.6	54.4	22.5	20.9	31
SEPTEMBER	19.1	19.0	47.7	49.1	20.2	19.3	30
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	31

SINGLE SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kW)
APRIL	0	0	0	0	0	0	
MAY	575	571	1450	1538	646	600	
JUNE	868	863	2212	2290	965	902	
JULY	1007	1011	2688	2863	1171	1071	
AUGUST	899	901	2366	2447	1014	940	
SEPTEMBER	831	827	2079	2141	881	841	
OCTOBER	0	0	0	0	0	0	
TOTAL	4181	4173	10796	11279	4678	4354	39462

TWO SPEED CONTROL (kWh)							TOTAL
	1-4	5-8	9-12	13-16	17-20	21-24	(kWh)
APRIL	0	0	0	0	0	0	
MAY	161	160	406	431	181	168	
JUNE	243	242	678	834	270	252	
JULY	282	283	1506	1855	328	300	
AUGUST	252	252	862	1023	284	263	
SEPTEMBER	233	232	582	599	247	236	
OCTOBER	0	0	0	0	0	0	
TOTAL	1171	1169	4034	4743	1310	1219	13644

VARIABLE SPEED COOLING TOWER CYCLING (kWh)							TOTAL (kWh)
	1-4	5-8	9-12	13-16	17-20	21-24	
APRIL	0	0	0	0	0	0	
MAY	12	11	188	224	17	13	
JUNE	43	42	713	791	59	48	
JULY	63	64	1199	1448	99	76	
AUGUST	45	45	818	904	64	51	
SEPTEMBER	38	37	592	646	45	39	
OCTOBER	0	0	0	0	0	0	
TOTAL	201	200	3510	4014	285	228	8437

[illegible]

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 6003EC5B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: TWO SPEED COOLING TOWER

ANALYSIS DATE: 04-11-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	9499.
B. SIOH	\$	523.
C. DESIGN COST	\$	570.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	9533.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	9533.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	106.	\$ 425.	11.37	4833.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		106.	\$ 425.		\$ 4833.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	-570.
(1) DISCOUNT FACTOR (TABLE A)	11.65	
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	-6641.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	-6641.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1595.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= _____		
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ -145.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ -1808.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= -0.19  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)  $SPB=1F/4$  -65.76

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-6  
**SYSTEM MODIFICATION:** HIGH EFFICIENCY MOTOR REPLACEMENT  
**SYSTEMS TO MODIFY:** PUMP & COOLING TOWER MOTORS

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-6, install high efficiency motors.  
 It was estimated that the electrical energy can be saved by installing high efficiency motors based on the motor operating hours per year.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	12	25,861	0	88

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 88 MMBtu/Yr X \$4.0141 /MMBtu = \$354 per year  
 Nat. Gas: 0 MMBtu/Yr X \$2.92 /MMBtu = \$0 per year  
**Total Energy Cost Savings: \$354 + \$0 = \$354 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 12 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$257 per year  
 Maintenance: = (-) \$0 per year  
**Total: \$257 - \$0 = \$257 per year**

[ECO-SHT.WK3]

# **HIGH EFFICIENCY MOTOR REPLACEMENT**

LABOR RATE:	19.6 \$/hr
ELECTRIC CONS.	0.0137 \$/kWH
ELECTRIC DEMAND	1.787 \$/kW

BLDG. NO.	EQUIPMENT SERVE	MOTOR HP	MOTOR FLA	MEAS AMPS	MEAS PF	MEAS VOLT	EXST EFF	NEW EFF	KW SVGS	HRS/ YEAR	KWH/YR SVGS	SVGS/ YEAR
5900	CWP-1	50.0	62.5	60	0.82	460	91.35%	93.00%	0.76	3672	2800	\$55
	CWP-2	60.0	69	53.6	0.88	460	92.52%	94.50%	0.85	2215	1884	\$44
	CWP-3	60.0	75	62	0.83	460	89.92%	94.50%	2.22	810	1796	\$72
	CWP-4	75.0	93	82.3	0.87	460	86.79%	93.60%	4.78	419	2003	\$130
	CWP-5	60.0	77	67	0.80	460	91.43%	94.50%	1.51	84	127	\$34
	CNWP-1	25.0	32	26.3	0.82	460	89.42%	91.70%	0.48	3672	1746	\$34
	CNWP-2	30.0	39.8	35.6	0.78	460	90.25%	92.40%	0.57	2215	1266	\$30
	CNWP-3	30.0	38	35.6	0.82	460	89.71%	92.40%	0.76	810	615	\$25
	CNWP-4	40.0	52	42.9	0.78	460	92.34%	93.00%	0.21	419	86	\$6
	CNWP-5	30.0	38	32	0.83	460	89.06%	92.40%	0.86	84	72	\$19
	CTM-1	25.0	31	27.2	0.87	460	86.79%	91.70%	1.16	2229	2592	\$60
	CTM-2	NI	NI	NI								
	CTM-3	NI	NI	NI								
	CTM-4	NI	NI	NI								
	CTM-5	20.0	24	24.6	0.87	460	89.69%	91.00%	0.27	84	23	\$6
	HWP(ret)-1	2.0	6.2	5.6	0.87	230	69.43%	84.00%	0.48	3624	1757	\$34
	HWP(ret)-2	2.0	6.2	5.4	0.87	230	69.43%	84.00%	0.47	3624	1694	\$33
	HWP(ret)-3	2.0	6.2	5.5	0.87	230	69.43%	84.00%	0.48	3443	1639	\$33
	HWP(ret)-4	2.0	6.2	5.3	0.87	230	69.43%	84.00%	0.46	2445	1122	\$25
	HWP(ret)-5	2.0	6.3	5.4	0.87	460	34.17%	84.00%	6.50	1720	11179	\$293
	HWP(sup)-6	2.0	6.2	5.5	0.87	230	69.43%	84.00%	0.48	910	433	\$16
	HWP(sup)-7	15.0	19.8	16.7	0.87	460	81.53%	90.20%	1.36	3624	4945	\$97
	HWP(sup)-8	20.0	24	15.2	0.87	460	89.69%	91.00%	0.17	2174.4	369	\$9
	HWP(sup)-9	20.0	25	15.6	0.86	460	87.51%	91.00%	0.47	2174.4	1015	\$24
	HWP(sup)-10	15.0	19.8	16.7	0.79	460	89.79%	90.20%	0.05	1449.6	77	\$5
	HWP(sup)-11	25.0	30	29	0.93	460	83.90%	91.70%	2.18	1449.6	3158	\$90
		<b>DEMAND CREDIT</b>		<b>\$590</b>	<b>MMBtu</b>	<b>145</b>	<b>TOTAL</b>		<b>28</b>		<b>42400</b>	<b>\$1,171</b>
6003	CWP-1	NI	NI	NI								
	CWP-2	50.0	62.5	44.6	0.81	460	92.48%	93.00%	0.18	3672	645	\$13
	CWP-3	50.0	62.5	46.4	0.87	460	86.10%	93.00%	2.77	3672	10181	\$199
	CNWP-1	NI	NI	NI								
	CNWP-2	30.0	37	32	0.84	460	90.38%	92.40%	0.52	3672	1905	\$37
	CNWP-3	30.0	37	31	0.87	460	87.26%	92.40%	1.37	3672	5029	\$98
	CTM-1	50.0	63	56.3	0.87	460	85.41%	93.00%	3.73	1087	4051	\$135
	CTM-2	50.0	63	56.3	0.87	460	85.41%	93.00%	3.73	1087	4051	\$135
		<b>DEMAND CREDIT</b>		<b>\$264</b>	<b>MMBtu</b>	<b>88</b>	<b>TOTAL</b>		<b>12</b>		<b>25861</b>	<b>\$618</b>

COST ESTIMATE ANALYSIS								INVITATION NO./CONTRACT NO.						EFFECTIVE PRICING		DATE PREPARED	
PROJECT ENERGY SURVEY OF ARMY BOILER AND CHILLER				DACA 59-90-C-0087				DATE APR. 91		10-Apr-91							
LOCATION FT. SILL, OKLAHOMA				<input type="checkbox"/> CODE A <input checked="" type="checkbox"/> CODE B <input type="checkbox"/> CODE C <input type="checkbox"/> OTHER _____				DRAWING NO.		SHT OF							
												CHECKED BY CEL					
MOTOR REP. ECO    BLDG. 6003				LABOR		EQUIPMENT		MATERIAL		TOTAL	SHIPPING						
HIGH EFF. MOTOR REPLACEMENT				No. Of Units	MH/ Unit	Total Hrs	Unit Price	Cost	Unit Price	Cost	Unit Wt	Total Wt					
TASK DESCRIPTION																	
CWP-2	50.0 HP MOTOR			1 EA	9.0	9.0	20	176	2579.0	2579.00	\$2,755						
CWP-3	50.0 HP MOTOR			1 EA	9.0	9.0	20	176	2579.0	2579.00	\$2,755						
CNWP-2	30.0 HP MOTOR			1 EA	6.0	6.0	20	117	1639.0	1639.00	\$1,756						
CNWP-3	30.0 HP MOTOR			1 EA	6.0	6.0	20	117	1639.0	1639.00	\$1,756						
CTM-1	50.0 HP MOTOR			1 EA	9.0	9.0	20	176	2579.0	2579.00	\$2,755						
CTM-2	50.0 HP MOTOR			1 EA	9.0	9.0	20	176	2579.0	2579.00	\$2,755						
SUBTOTAL								\$941		\$13,594	\$14,535						
OVERHEAD, BOND				16%				\$150		\$2,175	\$2,326						
PROFIT				10%				\$94		\$1,359	\$1,453						
COST SUB-TOTAL								\$1,185		\$17,128	\$18,314						
CONTINGENCY				20%				\$237		\$3,426	\$3,663						
SUBTOTAL								\$1,422		\$20,554	\$21,976						
S&A				5.5%				\$78		\$1,130	\$1,209						
TOTAL THIS SHEET								\$1,500		\$21,685	\$23,185						

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 6003EC6

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: HIGH EFF. MOTOR

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 25 YEARS PREPARED BY: KC

1. INVESTMENT
 

A. CONSTRUCTION COST	\$	21976.
B. SIOH	\$	1209.
C. DESIGN COST	\$	1319.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	22054.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	22054.

2. ENERGY SAVINGS (+) / COST (-)  
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	88.	\$ 354.	11.37	4030.
B. DIST	\$ .00	0.	\$ 0.	17.06	0.
C. RESID	\$ .00	0.	\$ 0.	16.85	0.
D. NAT G	\$ 2.92	0.	\$ 0.	17.52	0.
E. COAL	\$ .00	0.	\$ 0.	13.34	0.
F. TOTAL		88.	\$ 354.		\$ 4030.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	\$	257.
(1) DISCOUNT FACTOR (TABLE A)		11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1)	\$	2994.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)	\$	2994.
D. PROJECT NON ENERGY QUALIFICATION TEST		
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	1330.
A IF 3D1 IS = OR > 3C GO TO ITEM 4		
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)=		.24
C IF 3D1B IS = > 1 GO TO ITEM 4		
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY		

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ 611.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 7024.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .32  
(IF < 1 PROJECT DOES NOT QUALIFY)

\*\*\*\* Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 36.07

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO-7  
**SYSTEM MODIFICATION:** INSTALL INSTRUMENTATION TO DETERMINE LOAD  
**SYSTEMS TO MODIFY:**

**CALCULATION DESCRIPTION:**

Analysis spread sheet was prepared to determine the energy savings for ECO-7, install instrumentation to facilitate efficient operation of boiler plant. It was estimated that the energy wasted from boiler in standby is 1% of the rated output capacity. The hours when boilers are running unnecessary were estimated for each boiler.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	--	0
ECO	--	--	--	0
Savings (Baseline-ECO)	0	0	67	67

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity:	0 MMBtu/Yr	X	\$4.0141 /MMBtu	=	\$0 per year
Nat. Gas:	67 MMBtu/Yr	X	\$2.92 /MMBtu	=	\$196 per year
<b>Total Energy Cost Savings:</b>		<b>\$0 +</b>	<b>\$196</b>	<b>=</b>	<b>\$196 per year</b>

**NON-ENERGY SAVINGS (+), COST (-):**

Demand:	0 kW/month	X	\$1.787 /kW	X	12 months/year
	= (+)		\$0		per year
Maintenance:	= (-)		\$255		per year
<b>Total:</b>		<b>\$0 -</b>	<b>\$255</b>	<b>=</b>	<b>(\$255) per year</b>

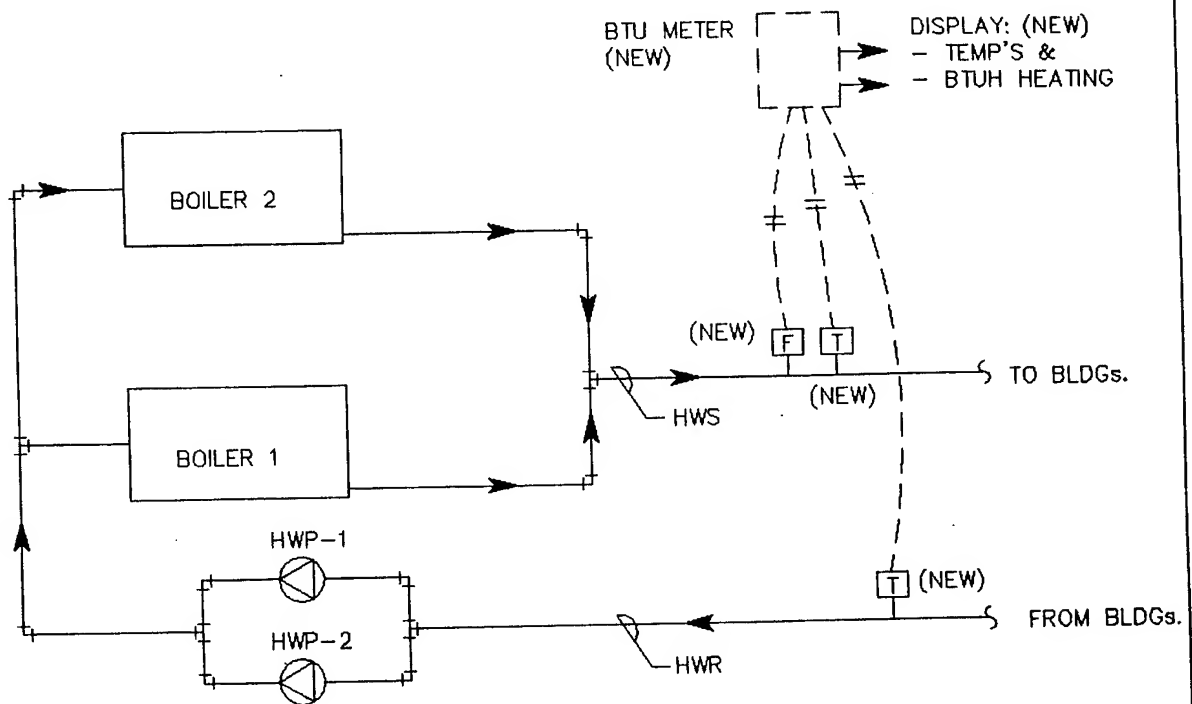
[ECO-SHT.WK3]

# BOILER STANDBY SAVINGS

CENTRAL PLANT	BOILER NO.	BOILER TYPE	BOILER MANUFACTURER	BOILER MODEL NUMBER	RATED BOILER OUTPUT MMBTU/H	CALC. BOILER OUTPUT MMBTU/H	STANDBY LOSS (1%) MMBTU/H	EXCESS STANDBY (HRS/YR)	EXCESS STANDBY MMBTU/H	EXCESS STANDBY SAVINGS (\$)
5900	1	HTHW	INTERNATIONAL	D-12	10.00	6.94	0.0694	0		
	2	HTHW	INTERNATIONAL	D-12	10.00	7.17	0.0717	720	51.62	\$150.74
	3	HTHW	HERCULES	300	9.70	7.61	0.0761	720	54.82	\$160.09
	4	HTHW	HERCULES	300	9.70	7.58	0.0758	720	54.55	\$159.27
	5	HTHW	INTERNATIONAL	1035 TH12	8.00	6.22	0.0622	0		
	6	HTHW	INTERNATIONAL	TJW-C-10	11.20	8.88	0.0888	0		
					TOTAL			2160	160.99	\$470.10
6003	1	STEAM-12	KEWANEE	L39-350-605	11.72	9.41	0.0941	0		
	2	STEAM-12	YORK SHIPLEY	SPL-350-112080	11.72	9.12	0.0912	0		
	3	STEAM-12	KEWANEE	L36-350-605	11.72	9.37	0.0937	720	67.45	\$196.96
					TOTAL			720	67.45	\$196.96
730	1	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	0		
	2	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.16	0.0616	720	44.34	\$129.47
	3	STEAM-12	KEWANEE	CAT#7L286-KX	7.75	6.18	0.0618	720	44.51	\$129.96
	4	STEAM-12	KEWANEE	CAT#7L280-KG-06	2.66	2.11	0.0211	0		
					TOTAL			1440	88.84	\$259.43
2812	1	STEAM-12	FEDERAL BOILER CO	GS 3562	1.80	1.40	0.0140	0		
	2	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.77	0.0277	0		
	3	HW	THERMO-PAK BOILER INC.	GW5500X	3.95	2.86	0.0286	720	20.62	\$60.21
					TOTAL			720	20.62	\$60.21
5676	1	HW	AMERICAN STANDARD	PF 515	2.44	1.80	0.0180	720	12.93	\$37.76
	2	HW	AMERICAN STANDARD	PF 515	2.44	1.71	0.0171	0		
					TOTAL			720	12.93	\$37.76
5678	1	HW	BRUNHAM	PF 514	2.27	1.50	0.0150	720	10.79	\$31.50
	2	HW	BRUNHAM	PF 514	2.27	1.63	0.0163	0		
					TOTAL			720	10.79	\$31.50
914	1	STEAM-12	BRUNHAM	PF-510	1.61	1.29	0.0129	0		
	2	HW	RAY-PAK	EA 200ITB	1.61	1.22	0.0122	0		
	3	HW	AMERICAN STANDARD	G1015	1.92	1.47	0.0147	720	10.56	\$30.84
	4	HW	AMERICAN STANDARD	G1015	1.92	1.40	0.0140	0		
					TOTAL			720	10.56	\$30.84
4701	1	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	0		
	2	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.00	0.0000	0		
	3	STEAM-100	BIRCHFIELD	FBH 578	11.00	8.43	0.0843	720	60.73	\$177.33
					TOTAL			720	60.73	\$177.33

[BOILERS.WK3]

# ECO-7, INSTRUMENTATION FOR BOILER PLANT (TYPICAL)



[F] FLOW METER  
[T] TEMPERATURE SENSORS

[B-ECO-7.DWG]

[illegible]

DA FORM 1-1, APR 85

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      STUDY: B6003EC1  
 LCCID 1.035  
 INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3  
 PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS  
 FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER INSTRUMENTATION  
 ANALYSIS DATE: 04-12-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	4248.
B. SIOH	\$	234.
C. DESIGN COST	\$	255.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	4263.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	4263.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	67.	\$ 197.	12.48	2458.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		67.	\$ 197.		\$ 2458.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	-255.
(1) DISCOUNT FACTOR (TABLE A)	9.11		
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	-2323.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4)		\$	-2323.
D. PROJECT NON ENERGY QUALIFICATION TEST			
(1) 25% MAX NON ENERGY CALC (2F5 X .33)	\$	811.	
A IF 3D1 IS = OR > 3C GO TO ITEM 4			
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= _____			
C IF 3D1B IS = > 1 GO TO ITEM 4			
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY			

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) \$ -58.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 135.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .03  
 (IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 -73.45

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 10  
**SYSTEM MODIFICATION:** OXYGEN TRIM FOR BURNERS  
**SYSTEMS TO MODIFY:** BOILER 1 AND 2

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-10, install oxygen trim for burners.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	--	--	71,623	71,623
ECO	--	--	71,173	71,173
Savings (Baseline-ECO)	0	0	450	450

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 0 MMBtu/Yr X \$4.0141 /MMBtu = \$0 per year  
 Nat. Gas: 450 MMBtu/Yr X \$2.92 /MMBtu = \$1,314 per year  
**Total Energy Cost Savings: \$0 + \$1,314 = \$1,314 per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 0 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$0 per year  
 Maintenance: = (-) \$1,187 per year  
**Total: \$0 - \$1,187 = (\$1,187) per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 6003 BASELINE-1

\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	71623.
PEAK DAY GAS CONSUMP., 1000 CU FT	703.
ELECTRICAL CONSUMPTION, KWH	976518.
PEAK KW DEMAND (15 MIN BASIS)	417.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	976518.
ON-PEAK KW DEMAND (15 MIN BASIS)	417.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2615
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 6003 BOILER ECO-4

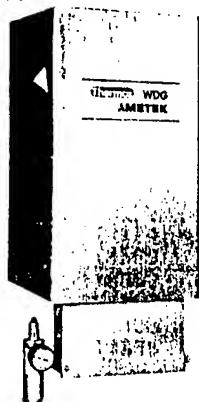
\*\* TOTAL \*\*

## SYSTEM C1 NORMAL HEATING AND COOLING LOADS

FUEL AND POWER CONSUMPTION	SYSTEM C1
TOTAL GAS CONSUMP., 1000 CU FT	71173.
PEAK DAY GAS CONSUMP., 1000 CU FT	703.
ELECTRICAL CONSUMPTION, KWH	976518.
PEAK KW DEMAND (15 MIN BASIS)	417.
PURCHASED ELECTRIC POWER	
ON-PEAK CONSUMPTION KWH	976518.
ON-PEAK KW DEMAND (15 MIN BASIS)	417.
MID-PEAK CONSUMPTION KWH	0.
MID-PEAK KW DEMAND (15 MIN BASIS)	0.
OFF-PEAK CONSUMPTION KWH	0.
OFF-PEAK KW DEMAND (15 MIN BASIS)	0.
GENERATED ELECTRICAL POWER KWH	0.
SOLD ELECTRICAL POWER KWH	0.
AUXILIARY FUEL CONSUMPTION	0.
DIR. PROC. GAS CONSUMP., 1000 CF	0.
CHILLER OPERATING HOURS	
CHILLER 1	3672
CHILLER 2	3672
BOILER OPERATING HOURS	
BOILER 1	3624
BOILER 2	2615
RECOVERABLE HEAT USED, MBTU	0.
RECOVERABLE HEAT UNUSED, MBTU	0.

# SPECIFICATIONS - AIR-MIZER II SYSTEM

## SENSOR



**Nominal Dimensions:** 14 1/4" H x 10 1/4" W x 10" D (37.2 x 26 x 25.4 cm)

**Enclosure:** Weather resistant—S.S. case, nickel plated carbon steel base

**Weight:** 55 pounds (25 kg)

**Accuracy:**  $\pm 1\%$  of net excess oxygen

**Repeatability:**  $\pm 0.2\%$  of measured value

**Response:** 90% of full scale in less than 5 seconds

**Drift:** Less than 0.1% of sensor cell output per month

**Ambient Temperatures:** -5 to +175°F (-20.5 to +79°C)

**Sample Temperatures:** Up to 1300°F (704°C) with standard probe

**Sample Flow Rate:** 0.1 to 120 scfh (0.47 to 56.65 liters/minute)

**Air Aspirator Requirements:** 10 to 20 scfh (4.72 to 14.16 liters/min) at 15-100 psi (1.05 to 7.037 kg/cm<sup>2</sup>) (Aspirator air regulator furnished with sensor normally set at 2-7 psi; 0.14 - 0.49 kg/cm<sup>2</sup>)

**Calibration:** With analyzed oxygen in nitrogen sample. Calibration port provided.

## CONTROL UNIT

**Nominal Dimensions:** 12 1/4" H x 10 1/4" W x 9 1/4" D (32.1 x 27.6 x 23.2 cm)

**Enclosure:** Wall/panel mounted—meets the requirements for NEMA 4 areas

**Weight:** 22 pounds (10 kg)

**Temperature Control:** On-Off by microprocessor ( $\pm 1^\circ\text{C}$ )

**Linearization:** 256 segments from 20% to 0.2% O<sub>2</sub>, (218 from 10% to 0.2%), by microprocessor

**Controller Action:** On-Off—"On" time adjustable 2-20 seconds. "Off" time adjustable 2-60 seconds.

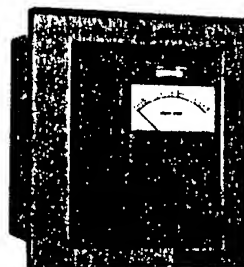
Deadband:  $\pm 0.25\%$  oxygen.

LED's indicate motor driving.

Will not allow decrease in air when O<sub>2</sub> is below 0.5% oxygen.

Air flow will increase to +15% max. if O<sub>2</sub> level is above 12%.

**Setpoint:** 0 to 10% oxygen by either of: A. Two banks of 5 slide pots, (Dual Fuel) selectable by slide switch; proper pot or pots connected to processor by switch in actuator. B. Manual pot on panel A or B selected by Remote/Local switch on panel. Setpoint indicated by edge reading meter (0-10%)



**Manual Control:** Manual/Auto switch and Increase—decrease push buttons (Spring return switch inside control unit can override all control actions in the event of processor failure).

**Ready Indicator:** On at temperature set point. Off below temperature set point. Flashes above temperature set point. O<sub>2</sub> Control in "manual" when below set point.

**Oxygen Scale:** 20.9 to 0.1% O<sub>2</sub>, Logarithmic

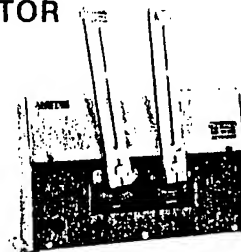
**Alarms:** High and Low O<sub>2</sub>, adjustable 0.2 to 20%. RTD Failure (shuts down temperature control, and puts O<sub>2</sub> control in "manual").

**Increase Air Override:** Contact closure from optional combustibles or smoke detector alarm will cause increase in air signal on each control pulse regardless of O<sub>2</sub> vs. O<sub>2</sub> setpoint relationship. Once combustibles contact opens, normal control will resume. This maintains air flow at a level where maximum allowable combustibles or smoke is not exceeded.

**Ambient Temperature Limits:** 32°F to 140°F (0 to +60°C)

**Recorder Output:** 0-100 mv = 0-20% O<sub>2</sub> Linear (0-50 mv = 0-10%) Other current or voltages outputs optional

## ACTUATOR



**Overall Size:** 17 1/2" L x 4" W x 10 1/4" H (44.5 x 10.2 x 26 cm)

**Weight:** 16.5 pounds (7.5 kg)

**Angular Travel (Input Arm):** 60°

**Linear Link Travel:** Adjustable 4" to 10" at 4" to 10" Radius (10.2 to 25.4 cm at 10.2 to 25.4 cm Radius)

**Linear Link Force:** 100 pounds at 4" Radius (45.5 kg at 10.2 cm Radius)  
70 pounds at 6" Radius (31.8 kg at 15.2 cm Radius)  
40 pounds at 10" Radius (18.2 kg at 25.4 cm Radius)

**Case:** Sulfatable for areas requiring NEMA 2 equipment (Drip proof indoor)

**Correction:** -15% to +15% (.85 to 1.15 gain) of normal air flow

**Speed:** 60 seconds from -15% to +15% correction (max.)

**Load Indication:** 9 position shorting switch tied to input arm

**Brake:** Internal brake will hold load at any above rated force without "coasting"

**Ambient Temperature Limits:** 0°F to 160°F (-18 to +71°C)



LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: 6003EC10

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID 1.035

INSTALLATION & LOCATION: FT. SILL, OKLAHOMA      REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: 3002-000 ENERGY SURVEY OF ARMY BOILER/CHILLERS

FISCAL YEAR 1991      DISCRETE PORTION NAME: BOILER O2 TRIM CONTROL

ANALYSIS DATE: 04-10-91      ECONOMIC LIFE 15 YEARS PREPARED BY: KC

1. INVESTMENT

A. CONSTRUCTION COST	\$	19036.
B. SIOH	\$	1047.
C. DESIGN COST	\$	1143.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	\$	19103.
E. SALVAGE VALUE COST	-\$	0.
F. TOTAL INVESTMENT (1D-1E)	\$	19103.

2. ENERGY SAVINGS (+) / COST (-)

ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 4.01	0.	\$ 0.	8.78	0.
B. DIST	\$ .00	0.	\$ 0.	12.34	0.
C. RESID	\$ .00	0.	\$ 0.	12.05	0.
D. NAT G	\$ 2.92	450.	\$ 1314.	12.48	16399.
E. COAL	\$ .00	0.	\$ 0.	10.01	0.
F. TOTAL		450.	\$ 1314.		\$ 16399.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)

(1) DISCOUNT FACTOR (TABLE A)      9.11

(2) DISCOUNTED SAVING/COST (3A X 3A1)      \$ -10814.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) \$ -10814.

D. PROJECT NON ENERGY QUALIFICATION TEST

(1) 25% MAX NON ENERGY CALC (2F5 X .33)      \$ 5412.

A IF 3D1 IS = OR > 3C GO TO ITEM 4

B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F= \_\_\_\_\_

C IF 3D1B IS = > 1 GO TO ITEM 4

D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS  $2F3+3A+(3B1D/(\text{YEARS ECONOMIC LIFE}))$  \$ 127.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) \$ 5585.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .29  
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)      SPB=1F/4      150.42

**ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS  
FT. SILL, OKLAHOMA**

**CENTRAL PLANT:** 6003  
**ENERGY CONSERVATION OPPORTUNITY:** ECO- 15  
**SYSTEM MODIFICATION:** GAS TURBINE ENGINES AND HEAT RECLAMATION  
**SYSTEMS TO MODIFY:** GAS TURBINE GENERATOR/ HEAT RECLAIM BOILER

**CALCULATION DESCRIPTION:**

Two PC-CUBE program computer runs are compared to determine the energy savings for ECO-15, install nat. gas turbine engines and heat reclaim.

The first computer run (Baseline) is a simulation of the existing structure, equipment, and systems, and how they are presently operated. The second computer run (ECO) is also a simulation of the existing building with modifications implemented in the systems, equipment, or the operation. The difference in the totals from the two computer runs represents the savings.

**ANNUAL UTILITY SAVINGS**

PC CUBE RUN	Electric		Nat. Gas (MMBtu)	Total Energy (MMBtu)
	Demand(kW)	Energy(kWh)		
Baseline	417	977,000	15,288	18,623
ECO	0	0	64,891	64,891
Savings (Baseline-ECO)	417	977,000	(49,603)	(46,268)

NOTE: The savings for this ECO did not consider any interrelated savings with other ECOs identified as economically feasible.

**ENERGY COST SAVINGS:**

Electricity: 3335 MMBtu/Yr X \$4.0141 /MMBtu = \$13,385 per year  
 Nat. Gas: -49603 MMBtu/Yr X \$2.92 /MMBtu = (\$144,841)per year  
**Total Energy Cost Savings: \$13,385 + (\$144,841) = (\$131,456) per year**

**NON-ENERGY SAVINGS (+), COST (-):**

Demand: 417 kW/month X \$1.787 /kW X 12 months/year  
 = (+) \$8,942 per year  
 Maintenance: = (-) \$3,000 per year  
**Total: \$8,942 - \$3,000 = \$5,942 per year**

[ECO-SHT.WK3]

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 6003 BASELINE-2

		***** PURCHASED ELECTRICAL *****									
		GAS	GAS	ON-PK	ON-PK	MID-PK	MID-PK	OFF-PK	OFF-PK	AUX	AUX
		DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	FUEL	FUEL
		MCF	MCF	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	CONSUMP	HRS
C1	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	4	113.	2997.	0.	0.	0.	0.	0.	0.	0.	0.
C1	5	112.	3098.	0.	0.	0.	0.	0.	0.	0.	0.
C1	6	114.	2997.	0.	0.	0.	0.	0.	0.	0.	0.
C1	7	112.	3098.	0.	0.	0.	0.	0.	0.	0.	0.
C1	8	113.	3098.	0.	0.	0.	0.	0.	0.	0.	0.
C1	9	113.	2997.	0.	0.	0.	0.	0.	0.	0.	0.
C1	10	112.	3098.	0.	0.	0.	0.	0.	0.	0.	0.
C1	11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Total gas consumption - May through September, 15,288 MMBtu

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 6003 BASELINE-1

		GAS		***** PURCHASED ELECTRICAL *****		*****		AUX			
		DEMAND	CONSUMP	ON-PK	ON-PK	MID-PK	MID-PK	OFF-PK	OFF-PK	FUEL	FUEL
		MCF	MCF	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	CONSUMP	HRS
				KW	THOU KWH	KW	THOU KWH	KW	THOU KWH		
C1	1	703.	20309.	0.	0.	0.	0.	0.	0.	0.	0.
C1	2	620.	15009.	0.	0.	0.	0.	0.	0.	0.	0.
C1	3	432.	11800.	0.	0.	0.	0.	0.	0.	0.	0.
C1	4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	5	0.	0.	248.	155.	0.	0.	0.	0.	0.	0.
C1	6	0.	0.	382.	199.	0.	0.	0.	0.	0.	0.
C1	7	0.	0.	414.	221.	0.	0.	0.	0.	0.	0.
C1	8	0.	0.	417.	221.	0.	0.	0.	0.	0.	0.
C1	9	0.	0.	335.	181.	0.	0.	0.	0.	0.	0.
C1	10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
C1	11	329.	8592.	0.	0.	0.	0.	0.	0.	0.	0.
C1	12	585.	15913.	0.	0.	0.	0.	0.	0.	0.	0.

Total electrical consumption - May through Septemeber 977,000 kWh  
 Peak electrical demand - August, 417 kW

PC-CUBE VERSION 2.0.3

CENTRAL PLANT 6003 COGENERATION, ELECTRIC MOTOR CHILLER

		GAS		ON-PK		ON-PK		PURCHASED ELECTRICAL		OFF-PK		OFF-PK		AUX		AUX	
		DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	DEMAND	CONSUMP	FUEL	FUEL		
		MCF	MCF	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	KW	THOU KWH	CONSUMP	HRS		
B1	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	5	398.	11954.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	6	455.	12916.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	7	467.	13806.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	8	469.	13818.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	9	432.	12396.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
B1	12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		

Total gas consumption.- May through September, 64,891 MMBtu

**APPENDIX E**

**FIELD SURVEY NOTES  
CHILLER-RELATED EQUIPMENT**

\*

## TEST INSTRUMENT INFORMATION

Contract No. DACA 56-90-C-0087.

Energy Study Army Boiler and Chiller Plants at Ft. Sill, Oklahoma.

#### TEST INSTRUMENTATION USED:

1. Flow meter:            Ultrasonic flow meter with clamp on probes.  
                              Dynasonics, Inc., Model Mark-3, Series 900, SN  
                              Purchased new August 1990, factory calibrated.  
                              Repeatability, linearity, and system accuracy, see specs.  
                              Used for chilled water and condenser water flow measurements.
  
2. Water temperature digital thermometers:  
                              Digital thermometer which can measure temperature 1, temperature 2, or  
                              delta temperature (T1-T2).  
                              Omega Meter, two, Model HH-23:Z1, SN T-54472 and T-54474.  
                              Temperature probes, four, Model HPS-CASS-14U-12-SMP-M, no SN  
                              Purchased new August 1990, factory calibrated.  
                              Accuracy, see specs.
  
3. Electric meter:        Digital power meter, measures amps, volts, kW, kVAR, KVA, for three  
                              phase circuits.  
                              Esterline Angus Power Master III AC Multimeter, SN3182  
                              Calibrated, 9/6/90.  
                              Accuracy, see specs.
  
4. Temperature and humidity digital meter:  
                              Digital temperature and humidity probe and meter for reading outside  
                              air conditions.  
                              General Eastern, Model 800B-2-9-7.  
                              Calibrated, 8/31/90.  
                              Accuracy, temperature +/-0.5oF , relative humidity +/- 2% RH.
  
5. Combustion gas monitor:  
                              Digital oxygen, CO, and temperature meter for boiler combustion  
                              monitoring.  
                              Neotronics, Model 350, Part No. 300-0266-03, SN 0200645.  
                              Purchased new 2/91, factory calibrated.  
                              Accuracy, see specs.
  
6. Pressure test gauges:  
                              Omega test gauge, 0-100 psig, 0.2 psi subdivisions, accuracy 0.25%.  
                              Omega test gauge, 0-30 psig, 0.1 psi subdivisions, accuracy 0.25%.  
                              Purchased new, 8/29/90, factory calibrated.

# Ultrasonic Flowmeter Mark-3<sup>™</sup> Series 900

**A New, Universal Non-Invasive Flowmeter For  
Liquids That Require No Solids Or  
Straight Run Of Pipe.**

**Dynasonics, a technological leader in Ultrasonic Flowmeters,  
has engineered all the latest technical advances in one Flowmeter.**

**□ Prompting Microprocessor**

- Self-Instructing Data Entry • Rate Readout in GPM, FPS, MGD, or Metric
- Volume Readout in Gals., or Metric • Set Span for 4-20 ma Output
- Select Damp Range • Rate and Total Volume Displays always indicate Units Selected
- Battery Backed Up Parameter Memory

**□ Digital Filtering; Auto Frequency Tracking**

- Tracks and Locks on Desired Frequency • Eliminates Undesired Error Frequencies
- Linearizes Turbulent/Unsymmetrical Flows • Allows Mounting Transducers without Straight Pipe Runs

**□ Auto Damping**

- Auto Adjusts Damping to Flow Rate Change
- Provides Steady Repeating at Stabilized Flow
- Rapidly tracks significant Flow Change
- Dynamic Process Tracking

**□ Easy Operation**

- Light Weight—Less than 18 Lbs.
- Operates with Cover Closed
- Self-Contained Battery w/charger
- One Hand Transducer Strap On

**□ Cost Effective**

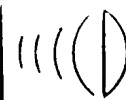
- Cost Reduction for Survey Measurements—Non-invasive
- Lower Cost than Flowmeters Producing Comparable Measurements
- Flow Measurements in Several Minutes, Without Special Pipe Preparation
- Virtually All Liquids, Independent of their Physical or Chemical Properties

**Clean/Dirty  
Liquids**



T-903  
TRANSDUCERS  
(Easy Strap-on)

**M3-902 PORTABLE  
SURVEY FLOWMETER  
(With Microprocessor)**



APPLICATION NOTE

DATE: 11/88  
REVISED: 4/89  
NUMBER: 1009

SPECIFICATIONS  
M3-900 FLOWMETER  
ULTRASONIC DOPPLER FOR CLEAN AND DIRTY LIQUIDS

GENERAL

The flowmeter shall be the latest state-of-the-art ultrasonic design utilizing the phase shift method, not requiring any suspended solids for operation. It will provide indicating and transmitting of flow rate in a full pipe. The operational specifications shall be: electronics repeatability and linearity,  $\pm 0.1\%$  full scale, total system accuracy of  $\pm 5\%$ . Unit can be field calibrated to 1% of field reference.

The meter shall operate on, but not be limited to the following pipe materials: carbon steel, ductile iron, cast iron, FRP and PVC. The ultrasonic flowmeter shall not require a spool section and shall operate on a straight section of pipe having homogeneous construction. Each meter shall respond to changes in flow when the medium is clear or contains suspended particles.

FLOWMETER ELECTRONICS

The electronics shall be housed in a NEMA IV enclosure and shall operate at temperatures between  $0^{\circ}\text{C}$  and  $50^{\circ}\text{C}$ . All electronic circuits will be coated with a mil-spec anti-fungus compound. The front of the housing shall be hinged to provide easy access to all controls and be suitable for wall or pipe stand mounting. The transmitter/indicator shall be capable of being calibrated for different flow ranges on 1" through 60" pipe sizes without replacement of any metering or sensing component. The transmitter shall include adjustment for mA span, mA 0, signal damping and for range calibration. The transmitter/indicator shall contain an internal range switch enabling the flow rate to be changed from 5, 10, 20 FPS. The flowmeter's electronic calibration can be checked by the optional microprocessor which induces a calibration frequency to assume full scale flow. The flowmeter electronics shall be powered by 120 VAC at 50/60 Hz.

A transformer isolated 4-20 mA output shall be provided and be proportional to flow. The maximum resisted load shall be 600 ohms. Output current limiting circuitry shall be provided.

## **M3-900 SPECIFICATIONS - PAGE 2**

The transmitter shall include recognition circuits to condition the signal being generated by the transducer. A digital filtering system shall discriminate between the desired linear signals and the non-linear signals at a point of non-symmetrical turbulence that is downstream of an elbow for accurate measurement of clean liquid applications. Unit's fault and read indication will verify operation on application.

### **TRANSDUCER**

The electronic flow sensing devices (transducers) shall be capable of being mounted to the outside of the pipe installed and removed without interrupting flow in the line. The transducers shall be of the piezo-electric type; one transducer with a transmit crystal, the other with a receive crystal. The transducers shall be designed to operate continuously at temperatures of up to 180°F. An adjustable strap shall be provided as a means of quickly mounting and demounting transducers.

The sensing element (transducer) shall be supplied as a dual weatherproof assembly with 20 ft. of flexible armoured conduit and shall be mounted on the pipe according to the manufacturer's recommendations.

### **MANUFACTURER**

The ultrasonic clean water flowmeter shall be the Dynasonics Model M3-900 or a pre-approved equal.

### **INSTALLATION SERVICES/START-UP**

The manufacturer's agent shall demonstrate like portable equipment to ensure that the correct doppler flowmeter is selected for the user's application.

# The Exceptional Digital Thermometers

## Models HH-22:Z1 and HH-23:Z1

- 0.1° Resolution in °F/°C for J, K, and T
- Dual Input with T1, T2 and  $\Delta T$  Measurement
- High Accuracy
- Trend Indication and Display Hold
- Max/Min Storage of T1, T2 and Difference
- Retention of User Programming

The HH-22 and HH-23 microprocessor-based digital thermometers are exceptional instruments, with innovations not previously available in a handheld. Innovations like a trend display and self-diagnostics, combined with 0.1% of reading accuracy, 0.1° F/C resolution, dual input, differential measurement, display hold, J, K and T type thermocouple inputs, and min/max data storage make the HH-22 and HH-23 extraordinary values.

These instruments are truly user-friendly. User-selected features, such as thermocouple type and units, are retained by the unit when power is shut off; when turned back on, the unit remembers these parameters, so reprogramming isn't necessary.

High accuracy and field portability are combined in the HH-22 and HH-23. Along with the other features, the case is drop, splash and dust proof, and has a built-in tilt stand/hanger for bench use or hands-free field measurements.

MADE IN

USA

### SPECIFICATIONS

**Inputs:** thermocouple, types J and K (HH23 has J/K/T)

**Display:** 5 digit LCD; custom indicators for input selection and type, units, HOLD, trend arrows, REC, MIN, MAX, VIEW, BAT

**Keypad:** 9 momentary switches with tactile feedback that select power, input type, units, resolution, hold, record/view min/max, stop/clear recording

#### Power Off Configuration

**Retention:** retention of selected readout, input type, units and resolution

**Diagnostics:** low battery, open thermocouple, invalid keypad entry, out of range, internal hardware fault

**Dimensions:** 7.0"H x 2.9"W x 1.1"D

**Weight:** 10 oz

**Repeatability:** 0.2°C

**Range, Type K:** -328 to 2502°F; -200 to 1372°C

**Range, Type J:** -346 to 1400°F; -210 to 760°C

**Range, Type T (model HH23 only):** -328 to 752°F; -200 to 400°C

**Resolution:** 0.1° throughout entire range

**Accuracy:**  $\pm(0.1\% \text{ rdg} + 1.0^\circ\text{F})$

**Temperature Coefficient:** 64 to 82.4°F, included in accuracy; 32 to 64°F and 82 to 122°F:  $\pm(0.02\% \text{ rdg} + 0.1^\circ\text{C})/^\circ\text{C}$

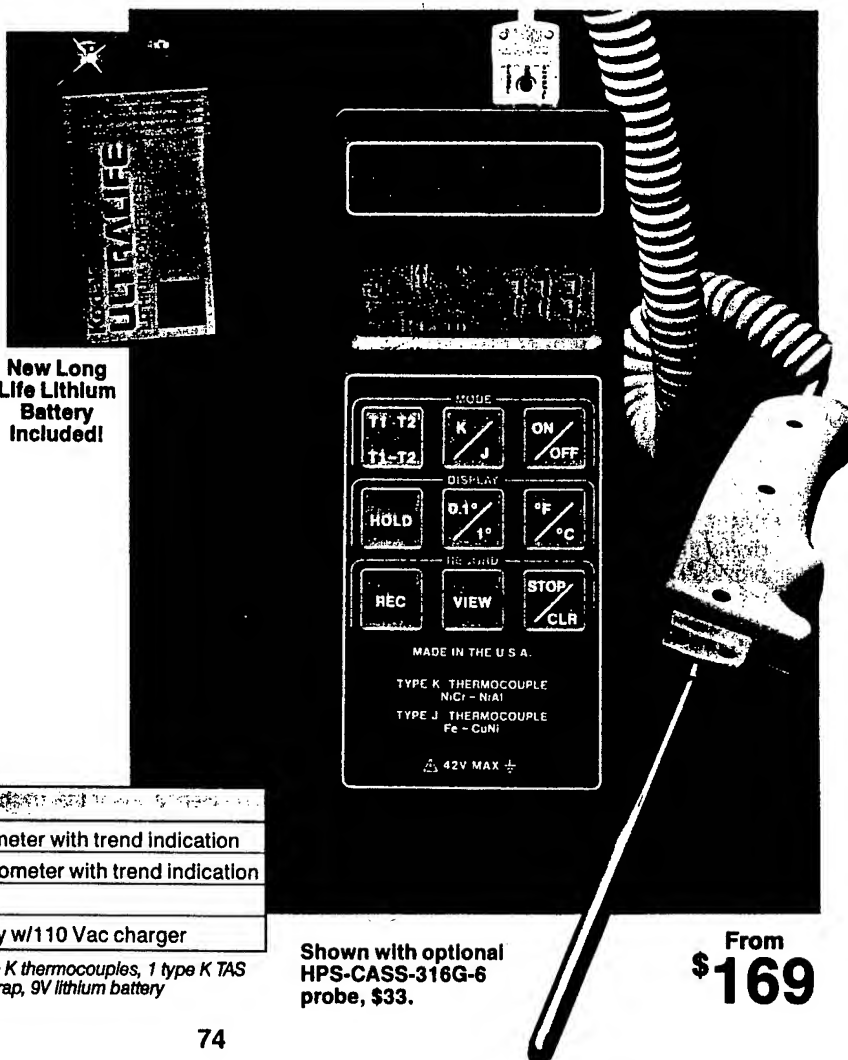
**Operating Environment:** 32 to 122°F, 0 to 80% RH

**Reading Rate:** 1 per second

**Max. Common Mode Voltage:** 42 V peak to earth ground

**Power:** 9 Vdc battery

**Battery Life, Continuous:** 200 h typical, lithium battery



New Long Life Lithium Battery Included!

### How to Order

Model No.	Price	Description
HH-22:Z1	\$169	J/K Digital Thermometer with trend indication
HH-23:Z1	189	J/K/T Digital Thermometer with trend indication
SC-800:Z1	10	soft carrying case
HH22-AC:Z1	30	9 Vdc NiCad Battery w/110 Vac charger

Each unit comes complete with 2 beaded wire type K thermocouples, 1 type K TAS transition adaptor, integral tilt stand/handle, wrist strap, 9V lithium battery

Shown with optional HPS-CASS-316G-6 probe, \$33.

From  
**\$169**

# Esterline Angus Power Master III AC Multimeter



PATENT PENDING

AMPS  
VOLTS  
K WATTS  
K VARS  
KVA  
POWER FACTOR  
PHASE ANGLE  
FIRING ANGLE



HVAC equipment analysis



Instrument complete with case and optional package for polyphase measurements.



Light circuit load survey analysis for commercial and industrial complexes



Switch gear 3-phase circuit analysis

### Model No. PM III

The Esterline Angus Power Master III AC Multimeter will measure all AC parameters on single and three-phase (balanced or unbalanced) power circuits. A process utilizing three full elements is employed, with transformer isolation built-in.

This highly versatile device uses a microprocessor to sample, square, average and square root the input waveform for true RMS voltages and currents. Voltage and current inputs are sampled simultaneously, then processed to provide readings in kw, kvar, kva, and Power Factor. An additional memory process is utilized to provide phase angle (sequence) and voltage firing angle for SCR analysis. This capability makes the device a must for checking distribution networks, panels, and individual loads, plus SCR controller operations.

All AC parameters measured can be read on the liquid crystal display and/or remotely recorded through the signal output jack. Individual voltages or currents, and single or total measurements of polyphase power parameters can be switch-selected. A HOLD switch position is provided to lock-in an instantaneous reading. Peak and Sag readings can also be recalled.

### Specifications

#### Measurements:

**Voltage:** To 600 VAC (rms)

**Current:** To 1000 AAC (rms)

**Watts:** 600 kw per element, 1800 kw total (3 el)

**VARS:** 600 kvar per element, 1800 kvar total (3 el)

**Volt-Amperes:** 600 kva per element, 1800 kva total (3 el)

**Power Factor:** 0.0 lag—1.0—0.0 lead, 1Ø or 3Ø, in percent

#### Current

**Transformer:** Clamp-on type operated by integral lever. Accepts 2" dia. wire or 1/2" x 2" rectangular bus.

**Case:** Hi-impact plastic case with detachable current transformer.

**Overall Dimensions:** 1 7/8" D x 3 1/2" W x 20" L (11" L without current transformer)

**Weight:** 2.5 pound-PM III

1.5 pound-Transformer

**Temperature:** Operating: 0° to 50°C (32° to 122°F)  
Storage: -20° to 75°C (-4° to 167°F)

Individual elements have color-coded input terminals, which are recessed for safety. Unit is battery powered, and will operate 15 hours continuously on one set of batteries.

**Frequency range:** 45-66 Hz, 400 Hz

#### Accuracy:

**Volts:** ± 1% Reading ± 0.3% FS ± 1 digit

**Amperes:** ± 1% Reading ± 0.3% FS ± 1 digit

**kw/kvar:** { 1Ø ± 2% Reading ± 0.4% FS ± 2 digits

**kva:** { 3Ø ± 3% Reading ± 0.4% FS ± 2 digits

Accuracies given are for currents above 10A.

Add 4% Reading accuracy for 400 Hz.

<b>Power Factor:</b>	1Ø and 3Ø	±0.9-1.0	45-66 Hz	400 Hz
		±0.0-±0.9	1% P.F.	4% P.F.
			2% P.F.	8% P.F.

Power Factor accuracies are for currents above 20A.

**Reading update:** Every 3 seconds for 1Ø, every 6 seconds for 3Ø.

**Recorder output:** 0-±1mA with up to 2k ohm load, accuracy ± 0.5%. Output at jack is same as parameter being displayed. (Except phase sequence and firing angle).

Voltage and current waveforms can be selected for waveform analysis on recorder output. Note: Accuracies stated above are for sinusoidal waves. SCR controllers with firing angles up to 120 degrees will have up to 4 percent additional inaccuracy.

The Power Master III AC Multimeter package includes a basic meter, one attachable current transformer, a set of 3-foot-long color-coded current and potential leads, one instruction manual, and a carrying case. Specify Model No. PM III. An optional package is available for polyphase circuit measurement, and consists of two additional current transformers, with color-coded current and potential leads. Specify Model No. PM III-Aux. The standard carrying case accommodates all hardware for polyphase measurements.



**Esterline Angus Instrument Corporation**  
Box 24000, Indianapolis, Indiana 46224  
Tel. 317-244-7611  
Cable: Estango Telex: 027-419



# Certificate of Calibration

**MODEL NO.** *PMIII*  
**INSTRUMENT** *Multimeter*

**SERIAL NO.** *3182*  
**MANUFACTURER** *Esterline Angus*

*Accuracy: per mfgs specs*

Calibration traceable to the National Institute of Standards and Technology in accordance with MIL-STD-45662A has been accomplished on the above-named instrument by comparison with standards maintained by E.I.L. Instruments. The accuracy and stability of all standards maintained by E.I.L. Instruments are traceable to national standards maintained by the National Institute of Standards and Technology in Washington, D.C. and Boulder, Colorado. Calibration was accomplished at a temperature of *70°F* and at a relative humidity of *51* per cent.

Complete record of all work performed is maintained by E.I.L. Instruments and is available for inspection upon request. The instrument ~~was~~ was not out of tolerance when initially received by E.I.L. Instruments, Inc.

Calibration Report No. 233483 Dated *9/6/90*  
Date Due *9/6/91*

Certified by:

A handwritten signature in cursive script, appearing to read "Chris Lee", is written over a horizontal line.

Quality Assurance Manager

## Traceability Data:

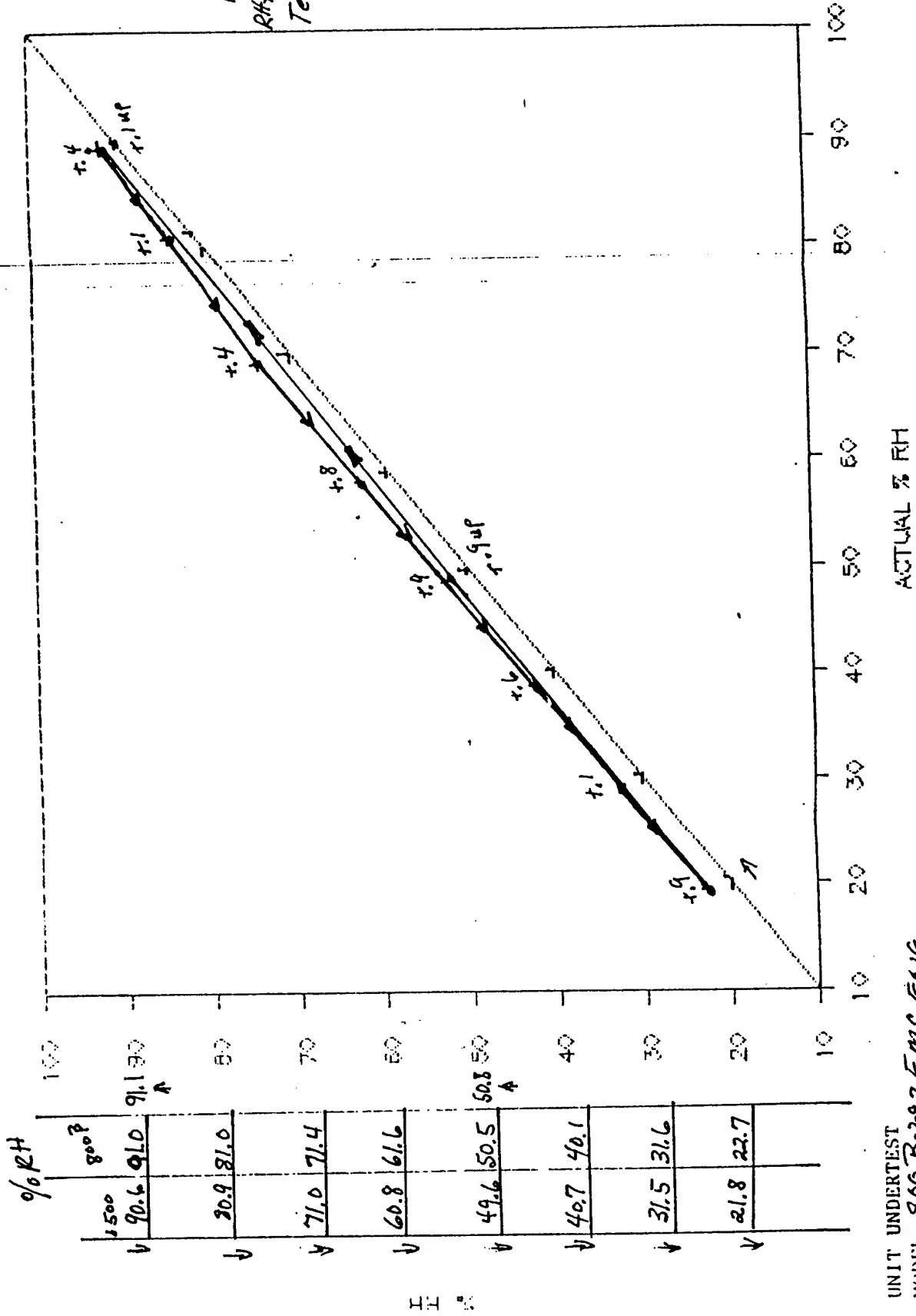
THOMAS 1 OHM STANDARD, NBS #240160, SEP 10, 1987  
1000 PICO FARAD CAPACITOR, NBS#242521, AUG 31, 1988  
100 MILLIHENRY INDUCTOR, NBS #241713, MAY 10, 1988  
GUILDLINE STANDARD CELL, NIST #243346, JUN 12, 1989  
AC/DC TRANSFER STANDARD, NBS #239605, JAN 10, 1989  
WWV TIME STANDARD, WWVB BY RECEIVER COMPARISON  
RF POWER STANDARD, NBS #2453A0676-001, DEC 21, 1988

Form 401, Rev. 5/88

STANDARD  
 GEI 15  
 SERIAL 5581  
 1211/P  
 S/N 3691  
 C-1 24745

Integrated Systems Technology  
 8/31/90

RH

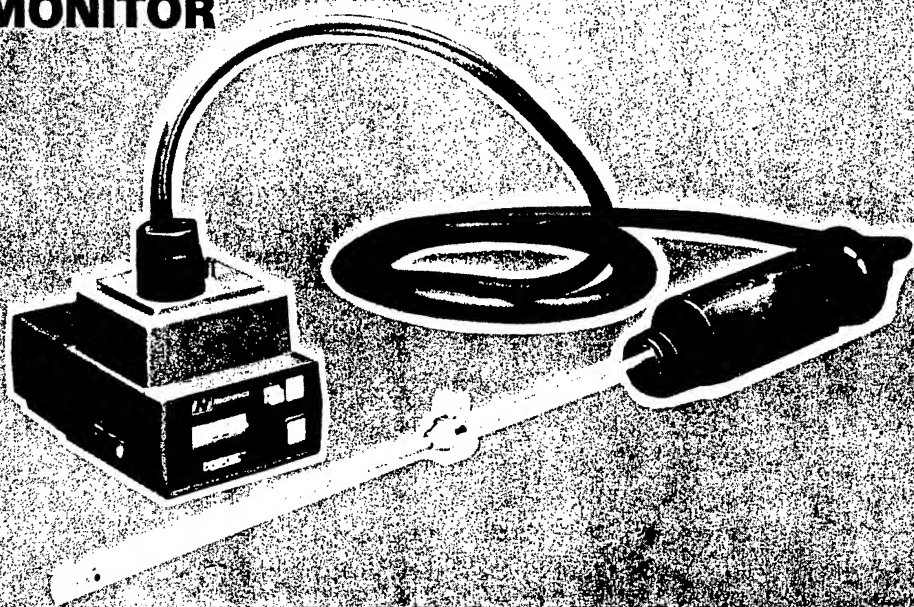


UNIT UNDER TEST  
 MODEL 800 B-2-97 EMC ENG  
 SERIAL N/A  
 DATE 8-31-90  
 DEVIATION  $\leq .9\%$  RHFS Temp =  $\leq .4\%$  FS.

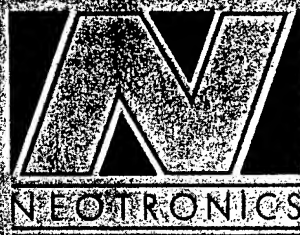
# OPTIFUEL<sup>®</sup>

MODEL 250 and 350

**COMBUSTION  
GAS  
MONITOR**



## **USER MANUAL**



A Member of the Neotronics PLC Technology Group

# CHAPTER 2 OPERATION OF THE OPTIFUEL

## 1.2 Specifications

**Power:** Custom NiCad Battery Pack 4.8V 2.0Ah  
**Battery Life:** 12 hours typical (continuous operation)  
**Charge Time:** 12 to 16 hours with OPTIFUEL Charger  
**Display:** 3 digit, 8mm Liquid Crystal Display  
**Operating Temperature:** 0°C (32°F) to 50°C (122°F)  
**Storage Temperature:** -10°C (14°C) to 55°C (131°F)  
**Probe Temperature:** 500°C continuous operation 1000°C max  
**Warm-up Time:** 40 seconds AUTOCAL routine  
**Response Time:** (To 80% of true reading when used with 3m of tubing, probe and filters)  
 Oxygen: less than 25 seconds  
 Carbon Monoxide: less than 40 seconds

## Display Ranges and Resolution:

Parameter	Range	Resolution
Oxygen	0 to 32.0%	0.1%
Carbon Monoxide (Autoselected)	0 to 999 ppm 0 to .999% 0 to 5.00%	1 ppm 0.001% 0.01%
E-12		
Temperature	OPTIFUEL 350 -20° to 999° (F or C)	

## Accuracy:

(with normal operating conditions)  
 Oxygen: Better than  $\pm 0.4\%$  of Oxygen  $\pm 1$  count  
 Carbon Monoxide: Better than  $\pm 5\%$  of reading  $\pm 1$  count  
 OPTIFUEL 350  
 Temperature: Maximum = Thermocouple error  $\pm 3\%$  of reading  $\pm 1$  count  
 Typical =  $\pm 1.5\% \pm 1$  count

## Case:

Heat-Resistant High Impact ABS  
 180mm x 100mm x 95mm (including battery pack)  
 Less than 1 kg (including battery pack)

## Dimensions:

## Weight:

## Note: Typical commercial thermocouple error:

$\pm 2.2^\circ\text{C}$  ( $-20^\circ$  to  $+227^\circ\text{C}$ )  
 or  $\pm 0.75\%$  ( $\pm 227^\circ\text{C}$  to  $+1260^\circ\text{C}$ )

## 2.1 Switch on

The OPTIFUEL monitor is supplied with its (fully charged) battery pack already connected. If the monitor has been in use and the battery is discharged, recharge the battery before using the monitor or use the monitor with the charger connected. Chapter 3 contains instructions for charging and mains operation.

**IMPORTANT NOTE: MAKE SURE THAT THE OPTIFUEL IS IN CLEAN FRESH AIR BEFORE SWITCHING IT ON. THIS IS VERY IMPORTANT AS THE 'AUTOCAL' ROUTINE WILL ADJUST THE CALIBRATION OF THE OPTIFUEL INCORRECTLY IF THE AMBIENT AIR IS NOT CLEAN AND FRESH.**

Switch the OPTIFUEL on by firmly depressing (and releasing) the "Power On/Off" button. DO NOT connect the probe, filters or tubing to the instrument at this time.

At switch on the OPTIFUEL displays a software code which identifies which version of software is built in. In an OPTIFUEL 350 PO8 monitors Fahrenheit and PO7 monitors Celsius. PO6 is an OPTIFUEL 250. All segments of the display will then momentarily illuminate and the pump will start operating. The pump generates a characteristic purring noise.

The instrument will now enter its 'AUTOCAL' mode. The display will flash an alphanumeric 'CAL'.

## 2.2 'AUTOCAL' Mode

When the OPTIFUEL is first switched on it enters the 'AUTOCAL' mode. In this mode the instrument's microprocessor assumes that the ambient conditions are that of fresh air (20.9% Oxygen and 0 ppm Carbon Monoxide). The microprocessor sets the Oxygen Span and Carbon Monoxide Zero calibration for these values.

While the OPTIFUEL is in AUTOCAL mode the display flashes 'CAL'. After approximately 40 seconds the instrument enters its Oxygen display mode (see section 2.5).

This automatic calibration adjustment can only be achieved if the two measured parameters are within a capture range "window". If the instrument is switched on with gas applied, or there is a fault, the measurement will be outside of the "window" and an error message will be displayed (see section 2.8b or 2.8c).

## 2.3.1 Sample System Connection for OPTIFUEL 250

Only connect the sample system after OPTIFUEL has completed its AUTOCAL routine.

Connect the probe to the inlet end of filter housing.

Connect one length of tubing between OPTIFUEL "inlet" port and the dust filter arrow on the filter shows the direction of flow. This arrow must point towards OPTIFUEL.

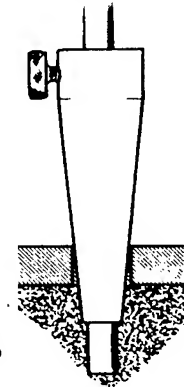
Connect the second length of gas between the other end of the dust filter the filter housing.

Adjust the sealing sleeve for the length of probe required and insert the probe in sampling hole. The sleeve acts as both a seal (for larger holes). Figs 2.3.1.a and 2.3.1.b illustrate the use of the sleeve.

Fig 2.3.1.a



Fig 2.3.1.b



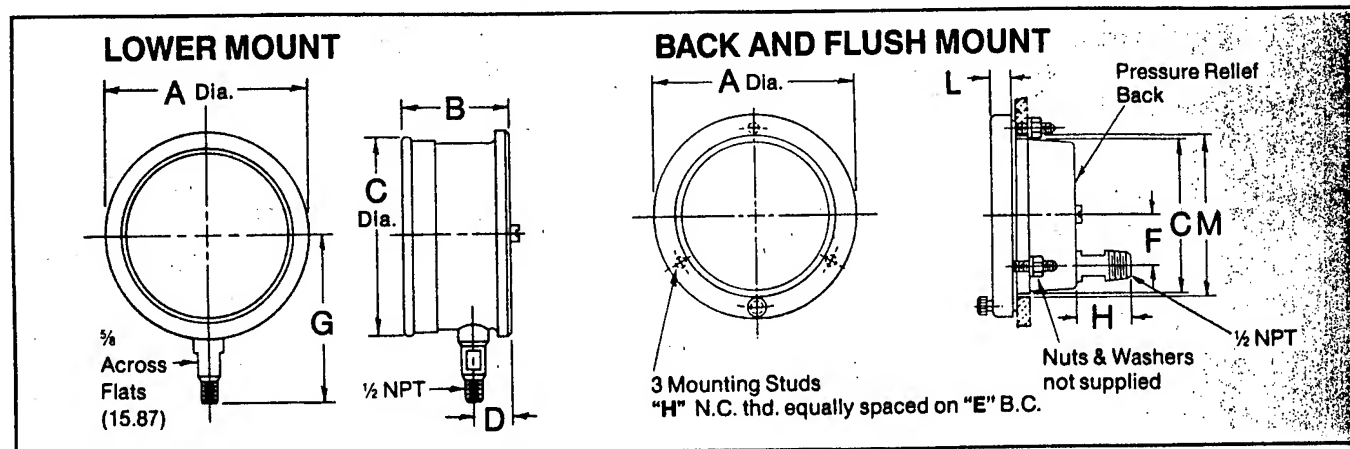
Figs. 2.3.1.a and 2.3.1.b Use of the probe

## 2.3.2 Sample System Connection for OPTIFUEL 350

As for the OPTIFUEL 250 only connect systems after the instrument has completed its AUTOCAL routine.

If the probe is not connected to the instrument the temperature reading unstable, ignore any temperature when the probe is not connected. Connect the system as indicated in Fig 2.3.2 that is: Instrument MALE to Extensi-

# TEST GAUGES—HIGH ACCURACY AND 316 STAINLESS STEEL WETTED PARTS



## LOWER MOUNT

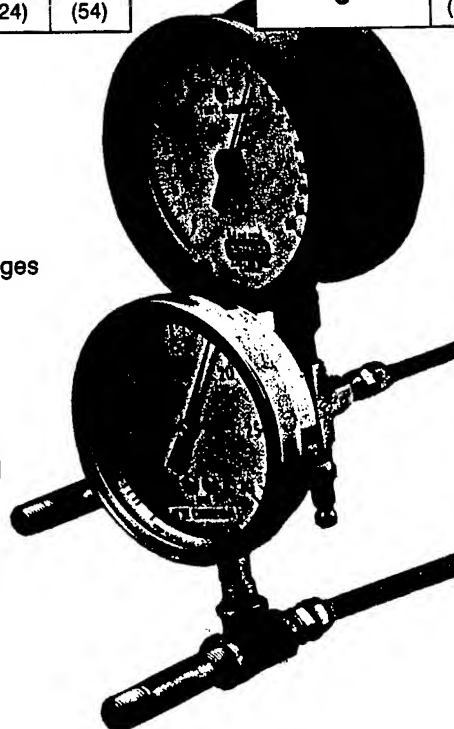
Dial Size Inches	A	B	C	D	G
4 1/2	5 1/8 (129)	2 37/64 (65)	5 1/8 (129)	1 5/8 (24)	3 13/16 (97)
6	6 1/8 (170)	2 19/32 (66)	6 37/64 (167)	1 5/8 (24)	2 1/4 (54)

## BACK AND FLUSH MOUNT

Dial Size Inches	A	C	F	H	L	M
4 1/2	6 1/8 (154)	4 13/16 (122)	1 5/8 (41)	1 7/8 (48)	5/8 (16)	4 7/8 (124)
6	7 7/8 (192)	6 5/8 (160)	2 1/8 (54)	1 7/8 (48)	5/8 (16)	6 1/2 (165)

## SPECIFICATIONS

**Case:** Solid Aluminum with Epoxy-coated Finish  
**Lower Connection:** Green Finish  
**Back Connection:** Black Finish  
**Window:** Glass  
**Movement:** Stainless Steel  
**Bourdon Tube:** 316 Stainless Steel thru 3000 PSI; Monel, 5000 and 10,000 PSI ranges  
**Connection:** 316 Stainless Steel  
**Fitting:** 1/2" NPT  
**Dial Size:** 4 1/2" with White Background, black graduations and mirror band.  
**Mounting: Stem:** Lower Connection  
**Panel or Stem:** Back Connection  
**Accuracy:** 0.25% FS  
**Ring:** Lower Connection Model-Threaded  
**Aluminum Back Connection Model-** Mounting Flange With Hinged Cover Ring Secured By Knurled Screw  
**Safety Features:** Solid Front With Pressure Relief Back



The OMEGA Test Gauges are highly accurate gauges designed for use in instrument shops, plants of all types, and laboratories throughout industry. Performance, reliability, and precision measurement are coupled with consistent accuracy in meeting the demanding service needs of various test gauge applications such as for use as a master reference gauge, in test stand measurements, for production inspection, and for verifying accuracy of general service gauges. The dial has a stainless steel mirror ring for pointer reflection to prevent parallax error. This mirror surface reflects the pointer in any position and allows the gauge to be read with great accuracy. The lightweight, friction adjustable balanced pointer with knife edge tip, assures easy reading to the smallest subdivision. The accented dial graduations have a true width equivalent to 0.25 percent tolerance for quick and accurate gauge checking.

**Warning:** All gauge components should be selected considering media and ambient operating conditions to prevent misapplication. Improper application can be detrimental to the gauge, cause failure, and possible personal injury or property damage.

## Ordering Example

1. Pressure Gauge, Test Type
2. Dial Size 4 1/2"
3. Connection—Lower (L) or Back (B)
4. Range Code—see pg. G-24

PGT-45 □ - Range Code

For Complete Listing of Stocked Test Gauges Refer to pg. G-24

# TEST GAUGES 4½" AND 6" DIALS TYPE T

MADE IN

**USA**

PRESSURE GAUGES **G**

## How To Order Type T — Test Gauges

Dial	Model	Connection	Vacuum to 1000 PSI	Price 1500 to 3000 PSI	5000 and 10000 PSI
4½"	PGT-45L-[*]	Lower	\$195	\$225	\$240
	PGT-45B-[*]	Back	195	225	240
6"	PGT-60L-[*]	Lower	231	282	341
	PGT-60B-[*]	Back	231	282	341

\*Insert Range Code from table below.

Options: (Add suffix to part number)

-X6B Gauge cleaned for oxygen service \$62

Ordering Example: PGT-45B-300: Pressure Gauge, Test Type, 4½" Dial, Back Connection, 0/300 PSI Range Price: \$240.

## Standard PSI Ranges Type T

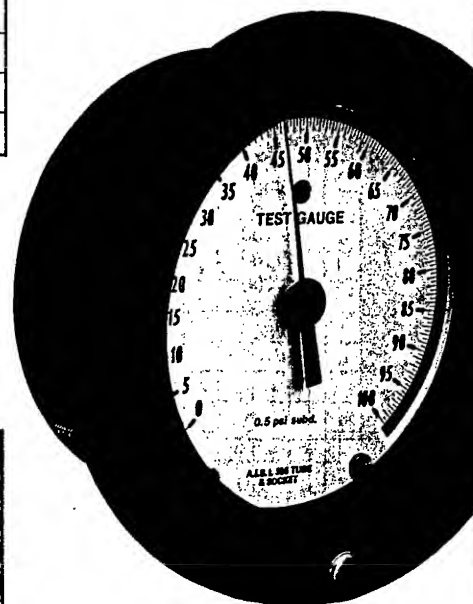
RANGE CODE	RANGE	FIGURE INTERVAL	MINOR GRADUATION
15	0/15	1	0.05
30	0/30	2	0.1
60	0/60	5	0.2
100	0/100	5	0.5
150	0/150	10	0.5
200	0/200	10	1
300	0/300	20	1
400	0/400	20	2
600	0/600	50	2
800	0/800	50	5
1000	0/1000(1)	50	5
1500	0/1500	100	5
2000	0/2000	100	10
3000	0/3000	200	10
5000	0/5000	500	10
10,000	0/10,000	1000	50
Vacuum			
30V	30/0" Hg	2" Hg	0.1" Hg
Compound			

Range Code	Range		Figure Interval		Minor Graduation	
	Inchs Mercury	PSI	Inchs Hg	PSI	Inchs Hg	PSI
30V/15	30" Hg Vac/0/15 PSI		5	2	0.25	0.1
30V/30	30" Hg Vac/0/30 PSI		10	5	0.5	0.2
30V/60	30" Hg Vac/0/60 PSI		10	5	1	0.5
30V/100	30" Hg Vac/0/100 PSI		10	5	2	0.5
30V/150	30" Hg Vac/0/150 PSI		30	10	2	1
30V/200	30" Hg Vac/0/200 PSI		30	20	2	1
30V/300	30" Hg Vac/0/300 PSI		30	20	5	1
30V/400	30" Hg Vac/0/400 PSI		30	20	5	1

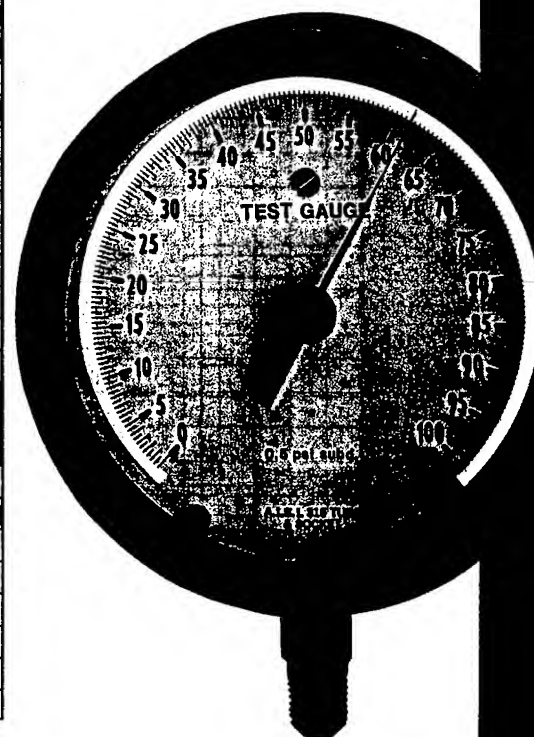
See page G-23 for special metric ranges.

◆ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ◆

G-24E-14



STYLE B



STYLE L

**NAME PLATE INFORMATION  
FOR  
CHILLER, CW & CNW PUMPS, AND COOLING TOWER  
(LISTED BY CENTRAL PLANT)**

**BLDG 730    CHILLER 1**

TYPE: 800 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE: 460V, 1650LRA, 821A, 3PH, 60Hz

MANUFACTURER: TRANE    SERIAL #L83H13856  
MODEL #CVHE-089F-AD-2WB2705DALC15DB-GC0000000061J00

REFRG TYPE: R-11

YEAR INSTALLED: 1983 (SPREADSHEET)

**BLDG 730    CHILLER 3**

TYPE: 320 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE: 480V, 797LRA, 367A, 3PH, 60Hz

MANUFACTURER: TRANE  
MODEL #CVHA-032G-HF-16JF2AZAF25AZA51100  
SERIAL #L80A06559

YEAR INSTALLED: 1980 (SPREADSHEET)

COMMENTS: ONLY RUNS IN SPRING & FALL WHEN CHILLER 1 (800 TON) IS  
NOT NEEDED.

**BLDG 730    CHILLER 4**

TYPE: 320 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE: 480V, 797LRA, 367A, 3PH, 60Hz

MANUFACTURER: TRANE  
MODEL # SAME AS CHILLER 3  
SERIAL #L80A06558

REFRG TYPE: R-11

YEAR INSTALLED: 1980 (SPREADSHEET)

COMMENTS: DOES NOT RUN BECAUSE OF A LEAK.

**BLDG 730 CW PUMP 1**

SERVES CHILLERS 1 & 3 FOR BLDG 730 ONLY

MOTOR

NAMEPLATE: 220/440V, 62 /31AMP, 3PH, 60Hz, 25 HP, 1750RPM

FRAME GROUTED? NO

**BLDG 730 CW PUMPS 1 & 2**

SERVES CHILLERS 1 & 3 FOR OTHER 700 AREA BLDGS.

MOTOR

NAMEPLATE: 460V, 179AMP, 3PH, 60Hz, 150HP, 1780RPM

FRAME GROUTED? NO

PUMP TYPE: PACO CAT #29-60196-050101 S #LWMF9912OA  
GPM: 1000 TDH-FT: 290  
IMP-DIA: 16.51"

PRESSURE TAPS ON: SUPPLY, RETURN

**BLDG 730 CNW PUMPS 1 & 2**

SERVES CHILLER 1 & 3

MOTOR

NAMEPLATE: 220/440V, 118/59AMP, 3PH, 60Hz, 50HP, 1760RPM

FRAME GROUTED? YES

PUMP TYPE: AURORA NO: 138230; TYPE: OJ; GPM: 200; TDH-FT: 75  
RPM: 1750  
DIM: 855X8

PRESSURE TAPS ON: SUPPLY, RETURN

**BLDG 730 CNW PUMP 3**

SERVES CHILLERS 1 & 3

MOTOR

NAMEPLATE: 200V, 90AMP, 3PH, 60Hz, 30HP 1760RPM

FRAME GROUTED? YES

PUMP TYPE: PACIFIC CAT #29-60122-040001-102  
GPM: 1300 TDH-FT: 75  
SERIAL: JLR28808

PRESSURE TAPS ON: SUPPLY, RETURN

**BLDG 730 COOLING TOWER FOR CHILLERS 1 & 3**

MANUFACTURER: MARLEY DOUBLE FLOW MODEL #N/A  
SERIAL #(452) 41008 75

NO. OF FANS: 2 230/460V, 71.4/35AMP, 3PH, 60Hz, 30HP

YEAR INSTALLED: 1980 (SPREADSHEET)

COMMENTS: COOLING TOWER WATER LEVEL TOO LOW OR SEPARATING  
BOARD TOO HIGH.

**BLDG 914 CHILLER 1**

TYPE: 400 TON CENTRIFUGAL

COMPRESSOR

NAMEPLATE: 460V, 711LRA, 339A, 3PH, 60Hz

MANUFACTURER: TRANE MODEL #CVHE-045F-CT-2LC235ECEIAIIDEEC-  
00000AIA25ZIAOCPL4533-9045-01  
SERIAL #L89J03103

REFRG TYPE: R-11

YEAR INSTALLED: 1989 (SPREADSHEET)

**BLDG 914 CW PUMP 1**

SERVES CHILLER 1

MOTOR

NAMEPLATE: 230/460V, 95.4/48AMP, 3PH, 60Hz, 40HP, 1775RPM

MOTOR TYPE: US ELECTRIC TYPE: CT FRAME: 324TTE  
ID #F208/807S115R031R-10

FRAME GROUTED? YES

PUMP TYPE: N/A

PRESSURE TAPS ON: SUPPLY, RETURN

COMMENTS: BOTH PUMPS HAVE DP SWITCH.

**BLDG 914 CNW PUMP 1**

SERVES CHILLER 1

MOTOR

NAMEPLATE: 230/460V, 39/19AMP, 3PH, 60Hz, 15HP, 1765RPM

MOTOR TYPE: US ELECTRIC ID #933/5085188R014F

FRAME GROUTED? YES

PUMP TYPE: AMW GPM: 950 TDH-FT: 31  
MODEL #6L3 SERIAL #129196

PRESSURE TAPS ON: SUPPLY, RETURN

**BLDG 914 COOLING TOWER FOR CHILLER 1**

MANUFACTURER: MARLEY MODEL #221-122 SERIES 220  
SERIAL #3-1385-89

NO. OF FANS: 2 460V, 15/5AMP, 3PH, 60Hz 10/2.5HP  
(2 SPEED)

YEAR INSTALLED: 1989 (SPREADSHEET)

**BLDG 2812 CHILLER 1**

TYPE: 372 TON CENTRIFUGAL

**COMPRESSOR**

NAMEPLATE: 480V, N/A LRA, 400A, 3PH, 60Hz

MANUFACTURER: CARRIER MODEL #19DG6667CP  
SERIAL #754324336

REFRG TYPE: R-11

YEAR INSTALLED: N/A (SPREADSHEET)

**BLDG 2812 CW PUMP 1**

SERVES CHILLER 1

**MOTOR**

NAMEPLATE: 230/460V, 54/27AMP, 3PH, 60Hz, 20HP, 1750RPM

MOTOR TYPE: UNICLOSED MOTOR FRAME: 256T

FRAME GROUTED? NO

PUMP TYPE: PACO NO: 4011-1 TYPE: KPG HORIZONTAL  
GPM: 416 TDH-FT: 95 RPM: 1750  
HP: 20 SPLIT CASE DOUBLE SUCTION

COMMENTS: NO NAMEPLATE; ALL INFORMATION FROM MANUAL

**BLDG 2812 CNW PUMP 1**

SERVES CHILLER 1

MOTOR

NAMEPLATE: 230/460V, 63/31.5AMP, 3PH, 60Hz, 25HP, 1760RPM

MOTOR TYPE: UNICLOSED FRAME: 284T TYPE: R

FRAME GROUTED: NO

PUMP TYPE: PACO NO:4011-7 TYPE: KPG HORIZONTAL  
SPLIT CASE GPM: 1092 TDH-FT: 55

**BLDG 2812 COOLING TOWER FOR CHILLER 1**

MANUFACTURER: MARLEY MODEL #8609 (SPREADSHEET)  
SERIAL #4-884-75

NO. OF FANS: 1

YEAR INSTALLED: N/A (SPREADSHEET)

**BLDG 3442 CHILLER 1**

TYPE: 600 TON CENTRIFUGAL

COMPRESSOR

NAMEPLATE: 460V, 3PH, 60Hz

MANUFACTURER: TRANE

MODEL #CVHE-063F-AQ-2PC2453CE1C11DEEC00-

0000004SZ1A0CPL4533-6519-01

SERIAL #L88K04614

REFRG TYPE: R-11

YEAR INSTALLED: 1988

**BLDG 3442 CHILLER 2**

TYPE: 600 TON CENTRIFUGAL

COMPRESSOR

NAMEPLATE: 460V, 3PH, 60Hz

MANUFACTURER: TRANE

MODEL #CVHE-063F-AQ-2PC2453CEZC11DEGC00-

0000004SZ1A0CPL4533-6518-01

SERIAL #L88K04613

REFRG TYPE: R-11

YEAR INSTALLED: 1988

**BLDG 3442 CW PUMPS 1 & 2**

SERVES CHILLERS 1 & 2

MOTOR

NAMEPLATE: 230/460V, 146/73AMP, 3PH, 60Hz, 60HP, 1774RPM

MOTOR TYPE: US ELECTRIC TYPE: RODP FRAME: 364TS

FRAME GROUTED? YES

PUMP TYPE: N/A

**BLDG 3442 CNW PUMP 1**

SERVES CHILLERS 1 & 2

MOTOR

NAMEPLATE: 230/460V, 104/52AMP, 3PH, 60Hz, 40HP, 1755RPM

MOTOR TYPE: GENERAL ELECTRIC MODEL #5K6237XM501G  
SERIAL #KXJ1003265

FRAME GROUTED? YES

PUMP TYPE: VERTI LINE #V85-70737 TYPE: 12FHH  
GPM: 1975 TDH-FT: 50 RPM 1760

COMMENTS: NO PRESSURE TAPS ON SUPPLY OR RETURN

**BLDG 3442 CNW PUMP 2**

SERVES CHILLERS 1 & 2

**MOTOR**

NAMEPLATE: 230/460V, 100/50AMP, 3PH, 60Hz, 40HP, 1760RPM

MOTOR TYPE: GENERAL ELECTRIC  
MODEL #5K6247XH4A

FRAME GROUTED? YES

PUMP TYPE: VERTI LINE GPM: 1975 TDH-FT: 50 RPM: 1760

COMMENTS: NO PRESSURE TAPS ON SUPPLY OR RETURN

**BLDG 3442 TWO COOLING TOWERS FOR CHILLERS 1 & 2**

MANUFACTURER: MARLEY MODEL #MRP4  
SERIAL #8609-4-2166-74B

NO. OF FANS: 4 15HP

YEAR INSTALLED: N/A

COMMENTS: WATER LEVEL IS LOW IN LOWER BASINS  
DIRECT DRIVE FANS  
WATER LEVELS IN UPPER BASINS NOT EQUAL

**BLDG 4701 CHILLERS 1 & 2**

TYPE: 305 TON CENTRIFUGAL

**COMPRESSOR**

NAMEPLATE: 460V, 378A, 3PH, 60Hz

MANUFACTURER: CARRIER MODEL #19DG6158CN  
SERIAL #730719401 and #731019729

YEAR INSTALLED: 1962

**BLDG 4701 CW PUMP 1 (NORTH)**

SERVES CHILLERS 1 & 2

**MOTOR**

NAMEPLATE: 440V, 60.7AMP, 3PH, 60Hz, 50HP, 1775RPM

MOTOR TYPE: MARATHON MODEL #IC365UTSC36AC  
FRAME: 365U

FRAME GROUTED? YES

PUMP TYPE: PACO GPM: 1320 TDH-FT: 100  
MODEL #5BB-KPGM SERIAL #1AA19029A  
IMP. DIA: 12"

COMMENTS: SOUTH PUMP DISCONNECTED (NEW MOTOR)

**BLDG 4701 CNW PUMPS 1 & 2**

SERVES CHILLERS 1 & 2

MOTOR

NAMEPLATE: 220/440V, 76/38A, 3PH, 60Hz, 30HP, 1770 RPM

MOTOR TYPE: MARATHON  
MODEL #ID326UTDR26CCW  
TYPE: TDR-BE FRAME: 326U

FRAME GROUTED? YES

PUMP TYPE: PACO GPM: 1650 TDH-FT: 52  
MODEL #8AW-KPGM SERIAL #1AA19028-A

COMMENTS: CNW PUMP 2 IS "OFF"

**BLDG 4701 TWO COOLING TOWERS FOR CHILLERS 1 & 2**

MANUFACTURER: GOODFELLOW MODEL #PVMA  
SERIAL #305-J399-1-79 & 305-J399-79

NO. OF FANS: 1 EACH 440V, 24.6A, 3PH, 60Hz, 20 HP

YEAR INSTALLED: N/A

COMMENTS: SOUTH TOWER FAN NOT RUNNING - COULD BE CYCLING.  
WATER IS GOING OVER TOWER  
THERE IS WATER IN SUMP BASINS  
COOLING TOWERS FREEZE UP IN WINTER  
NO BYPASS LOOP ON CONDENSER WATER

**BLDG 4701 COOLING TOWER FOR CHILLERS 1 & 2**

MANUFACTURER: MARLEY DOUBLEFLOW MODEL #351-4-772-73  
SERIAL #4-772-73

NO. OF FANS: 2 440V, 19.2AMP, 3PH, 60Hz, 15HP

YEAR INSTALLED: N/A

COMMENTS: SHAFT DRIVE & GEAR BOX  
- STEAM TRACER LINE TO COOLING TOWER DOES NOT WORK  
- INSULATION ON CNW PIPES IN POOR CONDITION

**BLDG 5676 CHILLER 1**

TYPE: 170 TON CENTRIFUGAL

**COMPRESSOR**

NAMEPLATE: 460V, 211FLA, 3PH, 60HZ

MANUFACTURER: CARRIER MODEL #19DG5132CB

SERIAL #73 42 20665

COMPRESSOR MODEL #19DH2132CB

SERIAL #28179

REFRG TYPE: R-11

YEAR INSTALLED 1967

COMMENTS: NO BRUSHES OR BRUSH VALVES ON CONDENSER

**BLDG 5676 CW PUMP 1 (TOP)**

SERVES CHILLER 1

MOTOR NAMEPLATE: 230/460, 27/13.5A, 3PH, 60Hz, 10HP, 1730RPM

MOTOR TYPE: US ELECTRIC ID #F-9242B-07-210

FRAME GROUTED? NO

PUMP TYPE: PACO CAT #1-25121-733201A01-2  
GPM: 270 TDH-FT: 90

COMMENTS: PRESSURE TAPS ON SUPPLY AND RETURN  
PUMPS MOUNTED ON RACKS  
BOTH CW PUMPS LOOK THE SAME AND RUN

**BLDG 5676 CNW PUMP 1**

SERVES CHILLER 1

MOTOR NAMEPLATE: 230/460V, 22/11A, 3PH, 60Hz, 7.5HP, 1165RPM

MOTOR TYPE: GENERAL ELECTRIC MODEL #5K 254AL 305

FRAME GROUTED? YES

PUMP TYPE: ALLIS CHALMERS SIZE & TYPE: 2000 MODEL: 150  
SERIAL #801-33958-1-1 GPM: 525  
TDH-FT: 30 DIM: 6X6X9 IMP.DIA: 8.9

COMMENTS: MOTOR LOOKS NEW

**BLDG 5676 COOLING TOWER FOR CHILLER 1**

MANUFACTURER: MARLEY MODEL: SUPER AQUATOWER  
SERIAL 471754-961-79B

NO. OF FANS: 1 460V, 10.5A, 3PH, 60Hz, 7.5HP

FAN MOTOR: DAYTON MODEL: 3N660A BELT SIZE: ZGB8162  
RPM: 1740 NEMA EFF: 87.5% PF: 79%

YEAR INSTALLED: 1986

COMMENTS: BELT DRIVE  
EXTERNAL MOTOR

**BLDG 5678    CHILLER 1**

TYPE:                    190 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE:            460V, 195A, 3PH, 60Hz

MANUFACTURER: TRANE  
                  MODEL #CVHE-020F-AC-2EB2502CAZA12CA1A000-  
                                  0000051A1A  
                  SERIAL #L82JO6486

REFRG TYPE:            R-11

YEAR INSTALLED: 1985

COMMENTS:            CHILLER SURGES BADLY WHEN APPROACHING PEAK CURRENT  
                          WHILE LOADING

**BLDG 5678    CW PUMP 1**

SERVES CHILLER 1

MOTOR  
NAMEPLATE:            230/460V, 50/25AMP, 3PH, 60Hz, 20 HP, 1755RMP

MOTOR TYPE:           STERLING    M #B0204FFF283

PUMP TYPE:            PACO GPM: 546    TDH-FT: 82  
                          MODEL #1BLH74    SERIAL #FID3402

PRESSURE TAPS ON: SUPPLY, RETURN

COMMENTS:            CW PUMP IS LEAKING VERY BADLY AROUND SEALS.

**BLDG 5678 CNW PUMP 1**

SERVES CHILLER 1

MOTOR

NAMEPLATE: 230/460V, 22/11AMP, 3PH, 60Hz, 7.5HP, 1165RPM

PRESSURE TAPS ON: SUPPLY, RETURN

COMMENTS: NO NAMEPLATE INFO WAS TAKEN

**BLDG 5678 COOLING TOWER FOR CHILLER 1**

MANUFACTURER: MARLEY      MODEL: SUPER AQUATOWER  
SERIAL #47175 4-961-79A

NO. OF FANS: 1

YEAR INSTALLED: 1980

COMMENTS: TOWER WATER TREATMENT SYSTEM APPARENTLY NOT WORKING

**BLDG 5900    CHILLER 1**

TYPE: 400 TON CENTRIFUGAL

NAMEPLATE: 460V, 2347LRA, 476A, 3PH, 60Hz

MANUFACTURER: CARRIER,    MODEL #19DG6968CQ  
SERIAL #77 18 26211

REFRG TYPE: R-11

YEAR INSTALLED: 1980 (SPREADSHEET)

COMMENTS: BOTH CWS & CWR NEED INSULATION AT POINTS OF ENTRY INTO CHILLER

**BLDG 5900    CHILLER 2**

TYPE: 400 TON CENTRIFUGAL

COMPRESSOR: 460V, 783LRA, 438A, 3PH, 60Hz, N/A HP  
NAMEPLATE

MANUFACTURER: WESTINGHOUSE    MODEL #TC 418 B  
SERIAL #DY95

REFRG TYPE: R-12

YEAR INSTALLED: 1982 (SPREADSHEET)

COMMENTS: COOLING TOWER UNDERSIZED  
COOLING TOWER LOOKS TO BE OPERATING FINE  
- GETTING TO HIGH CNW TEMPERATURES

**BLDG 5900    CHILLER 3**

TYPE: 400 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE: 480V, 692LRA, 346A, 3PH, 60Hz

MANUFACTURER: CARRIER    MODEL #19DK7687CN  
SERIAL #85 05 365 14

YEAR INSTALLED: 1988 (SPREADSHEET)

COMMENTS: CHILLED WATER PUMP DISCHARGE VALVE RATTLES.

**BLDG 5900    CHILLER 4**

TYPE:                    450 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE:            480V, 816LRA, 501A, 3PH 60Hz

MANUFACTURER: McQUAY    MODEL #PE HO 76  
   SERIAL #5 RFO 300 700

REFRG TYPE:            R-500

YEAR INSTALLED: 1989 (SPREADSHEET)

COMMENTS:            CHILLER METERS NOT FUNCTIONING PROPERLY  
                                 UNIT NOT RUNNING AT TIME OF SURVEY

**BLDG 5900    CHILLER 5**

TYPE:                    400 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE:            460V, 1044LRA, 399A, 3PH 60Hz,

MANUFACTURER: CARRIER    MODEL #19DK78404CQ    SERIAL #87 15 39461

YEAR INSTALLED: 1988 (SPREADSHEET)

COMMENTS:            HAS EMCS INPUT TERMINALS READY

**BLDG 5900 CW PUMP 1**

SERVES CHILLER 1

MOTOR NAMEPLATE: 230/460V, 125/62.5AMP, 3PH, 60Hz, 50HP, 1770RPM  
MOTOR TYPE: LINCOLN FRAME: 326T  
FRAME GROUTED? NO  
PUMP TYPE: PEERLESS SIZE: 3AD 15 1/2 TYPE:5300  
RPM: 1750 GPM: 700 TDH-FT: 190  
SERIAL #384899

**BLDG 5900 CW PUMP 2**

SERVES CHILLER 2

MOTOR  
NAMEPLATE: 230/460V, 138/69AMP, 3PH, 60Hz, 60 HP, 3535RPM  
MOTOR TYPE: MARATHON MODEL #326TSTD 700ICE W  
FRAME GROUTED? YES  
PUMP TYPE: AURORA #60-00072-1 TYPE: 411 BF  
GPM: 700 TDH-FT: 190 RPM:3500  
SIZE 3X4X10B  
COMMENTS: PRESSURE & TEMP. TAPS ON SUPPLY & RETURN

**BLDG 5900 CW PUMP 3**

SERVES CHILLER 3

MOTOR  
NAMEPLATE: 230/460V, 151/75AMP, 3PH, 60Hz, 60HP, 1780RPM  
FRAME GROUTED? NO  
MOTOR TYPE: US ELECTRIC ID #R-9420-03-971  
PUMP TYPE: BELL & GOSSETT ID #A58  
GPM: 700 TDH-FT: 190 RPM: 1750 HP:60  
MODEL #VSCS-S13-1/2 BFLHR  
SERIAL #1261 301 DIM:4X5X14 3/4

**BLDG 5900 CW PUMP 4**

SERVES CHILLER 4

MOTOR

NAMEPLATE 230/460V, 186/93AMP, 3PH, 60Hz, 75HP, 1775RPM

MOTOR TYPE: MARATHON ELECTRIC M #SJ 365TSTD 7026JPW

FRAME GROUTED? NO

PUMP INACCESSIBLE BECAUSE OF INSULATION

**BLDG 5900 CW PUMP 5**

SERVES CHILLER 5

MOTOR

NAMEPLATE: 230/460V, 154/77AMP, 3PH, 60Hz, 60HP, 1775 RPM

MOTOR TYPE: MARATHON M #364TSTD 7026JP W  
TYPE: TDS

FRAME GROUTED? NO

PUMP TYPE: BELL & GOSSETT GPM: 700 TDH-FT: 293 RPM: 1750  
HP: 60 MODEL #VSCS 13 5/8-BF RHR  
DIM: 4X5X14 3/4 SERIAL #1358472

**BLDG 5900 CNW PUMP 1**

SERVES CHILLER 1

MOTOR

NAMEPLATE: 230/460V, 64/32AMP, 3PH, 60Hz, 25HP, 1750RPM

MOTOR TYPE: CENTURY PART TYPE: 6-320819-01, TYPE: SC

FRAME GROUTED? NO

PUMP TYPE: PEERLESS SIZE: 6AD-10 TYPE: 5300  
GPM: 1200 TDH-FT: 61 RPM: 1750  
SERIAL 386072

**BLDG 5900 CNW PUMP 2**

SERVES CHILLER 2

MOTOR

NAMEPLATE: 230/460V, 79.6/39.8AMP, 3PH, 60Hz, 30HP, 1755RPM

MOTOR TYPE: US ELECTRIC MODEL #R-6317-04-667 N

FRAME GROUTED? YES

PUMP TYPE: AURORA NO. #30-00071-1  
GMP: 1200 TDH-FT: 75 RPM: 1750 DIM: 5X6X11

COMMENTS: PRESSURE & TEMP. TAPS ON SUPPLY & RETURN

**BLDG 5900 CNW PUMP 3**

SERVES CHILER 3

MOTOR

NAMEPLATE: 230/460V, 76.2/38AMP, 3PH, 60Hz, 30HP, 1760RPM

MOTOR TYPE: US ELECTRIC ID #F-6317-07-073

FRAME GROUTED? NO

PUMP TYPE: BELL & GOSSETT ID #A58 GPM: 1200  
TDH-FT: 75 RPM: 1750 HP: 30  
MODEL #VSCS-59 3/8-BF RHR SERIAL #257911  
DIM: 6X8X9 3/4H

**BLDG 5900 CNW PUMP 4**

SERVES CHILLER 4

MOTOR

NAMEPLATE: 230/460V, 104/52AMP, 3PH, 60Hz, 1765RPM

MOTOR TYPE: MARATHON MODEL #TA 324TT DR 7026HNW

FRAME GROUTED? NO

PUMP TYPE: BELL & GOSSETT M #VSCS 9 5/8 BFR HR  
GPM: 1350 TDH-FT: 75 RPM: 1750  
HP: 40 DIM: 6X8X93/4-H

**BLDG 5900 CNW PUMP 5**

SERVES CHILLER 5

MOTOR

NAMEPLATE: 230/460V, 76.2/38AMP, 3PH, 60Hz, 30HP, 1760RPM

MOTOR TYPE: US ELECTRIC ID #6317/NION227RO51F

FRAME GROUTED? NO

PUMP TYPE: BELL & GOSSETT ID #E78 GPM: 1200 TDH-FT:75  
RPM: 1750 HP: 30  
MODEL #VSCS 9 3/8-BF RHR SERIAL #1391148

**BLDG 5900 COOLING TOWER FOR CHILLER 1**

MANUFACTURER: GOODFELLOW MODEL #PBM 400  
SERIAL #760 416

NO. OF FANS: 1

YEAR INSTALLED: 1980 (SPREADSHEET)

COMMENTS: COOLING TOWER HAS NO VISIBLE NAMEPLATE, SO ALL  
INFORMATION WAS TAKEN FROM CENTRAL PLANT  
SPREADSHEET.  
HAS SHALLOW BASIN SUMP.  
COULD BE UNDERSIZED.

**BLDG 5900 COOLING TOWER FOR CHILLER 2**

MANUFACTURER: GOODFELLOW MODEL #SDF-4250  
SERIAL #J-314-80

NO. OF FANS: 1

YEAR INSTALLED: 1982 (SPREADSHEET)

COMMENTS: FAN IS 2 SPEED SWITCH BROKEN, RUNNING IN "HIGH")  
TOWER UNDERSIZED  
3 WAY VALVE ON TOWER  
2 THERMOSTATS (2 SPEED FAN, AND 3 WAY VALVE)  
BELT DRIVE TOWER  
HAS SHALLOW BASIN SUMP

**BLDG 5900 COOLING TOWER FOR CHILLER 3**

MANUFACTURER: BALTIMORE AIRCOIL CO.  
MODEL #24220  
SERIAL #84-5818D (SPREADSHEET)

NO. OF FANS: 1

YEAR INSTALLED: 1988 (SPREADSHEET)

COMMENTS: BELT DRIVE TOWER  
2 SPEED FAN MOTOR  
3 WAY VALVE ON TOWER  
HAS SHALLOW BASIN SUMP  
TOWER COULD BE UNDERSIZED

**BLDG 5900 COOLING TOWER FOR CHILLER 4**

MANUFACTURER: MARLEY MODEL #222-521  
SERIAL #3-894-87

NO. OF FANS: 1 460V, 30/14A, 3PH, 60Hz, 25/6.2HP

YEAR INSTALLED: 1989 (SPREADSHEET)

COMMENTS: 2 SPEED FAN  
UNIT NOT RUNNING PRESENTLY  
3 WAY VALVE ON TOWER  
2 THERMOSTATS (2 SPEED FAN & VALVE)

**BLDG 5900 COOLING TOWER FOR CHILLER 5**

MANUFACTURER: MARLEY      MODEL #222-511  
SERIAL #3-484-88

NO. OF FANS:      1      460V, 24/8AMPS, 3PH, 60Hz, 20/5HP

YEAR INSTALLED: 1988 (SPREADSHEET)

COMMENTS:              2 SPEED FAN  
                             3 WAY VALVE ON TOWER  
                             2 THERMOSTATS (2 SPEED FAN & VALVE)

**BLDG 6003    CHILLER 1**

TYPE: 400 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE: 460V, 876LRA, 555A, 3PH, 60Hz

MANUFACTURER: TRANE CENTRAVAC    SERIAL #L81B21810  
MODEL #CV11A-044F-HH-09LH1AYAH1SA1A51600

REFRG TYPE: R-11

YEAR INSTALLED: 1984 (SPREADSHEET)

COMMENTS: SURGED TOO DRASTICALLY TO CHECK

**BLDG 6003    CHILLER 2**

TYPE: 450 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE: 480V, N/A LRA, 400A, 3PH, 60Hz

MANUFACTURER: TRANE CENTRAVAC    SERIAL #L86D37156  
MODEL #CVHE-0456-AH-2KB2371CE3C13DEFC000-00000-21J00

REFRG TYPE: R-11

YEAR INSTALLED: 1986 (SPREADSHEET)

**BLDG 6003    CHILLER 3**

TYPE: 450 TON CENTRIFUGAL

COMPRESSOR  
NAMEPLATE: 480V, N/A LRA, 400A, 3PH, 60Hz

MANUFACTURER: TRANE CENTRAVAC    SERIAL #L86D37155  
MODEL #CVHE-045G-AH-ZKB2378CE3C13EFC-0000000021J00

REFRG TYPE: R-11

YEAR INSTALLED: 1986 (SPREADSHEET)

COMMENTS: CONTROLS HUNT

**BLDG 6003 CW PUMP 1**

SERVES CHILLER #1

MOTOR

NAMEPLATE: 230/460V, 125/62.5AMP, 3PH, 60Hz, 50HP, 1770RPM

MOTOR TYPE: LINCOLN AC CODE: TV-3596 FRAME: 326 T  
S #2383663

FRAME GROUTED? N/A

PUMP TYPE: N/A

**BLDG 6003 CW PUMP 2**

SERVES CHILLER 2

MOTOR

NAMEPLATE: 230/460V, 125/62.5AMP, 3PH, 60Hz, 50HP, 1770RPM

MOTOR TYPE: LINCOLN S #2383664 FRAME: 326T

FRAME GROUTED? N/A

**BLDG 6003 CW PUMP 3**

SERVES CHILLER 3

MOTOR

NAMEPLATE: 230/460V, 125/62.5AMP, 3PH, 60Hz, 50HP, 1770RPM

MOTOR TYPE: LINCOLN CODE #TV 3596 FRAME: 286T  
SERIAL #3021542

FRAME GROUTED? N/A

**BLDG 6003 CNW PUMP 1**

SERVES CHILLER 1

MOTOR

NAMEPLATE: 230/460V, 70/37AMP, 3PH, 60Hz, 30HP, 1765RPM

MOTOR TYPE: MARATHON ELECTRIC      MODEL #BE286TTDR7026CDW  
FRAME: 286T  
TYPE: TDR-BE

FRAME GROUTED? N/A

PUMP TYPE: N/A

**BLDG 6003 CNW PUMP 2**

SERVES CHILLER 2

MOTOR NAMEPLATE: 230/460V, 74/37AMP, 3PH, 60Hz, 30HP, 1770RPM

MOTOR TYPE: LINCOLN      CODE: TV 3753      FRAME: 286T

FRAME GROUTED? N/A

**BLDG 6003 CNW PUMP 3**

SERVES CHILLER 3

MOTOR NAMEPLATE: 230/460V, 70/37AMP, 3PH, 60Hz, 30HP, 1765RPM

MOTOR TYPE: MARATHON      M #BE286TTDR7026CDW  
FRAME: 2865      TYPE: TDR-BE

FRAME GROUTED? N/A

PUMP TYPE: N/A

PRESSURE TAPS ON: N/A

**BLDG 6003 COOLING TOWER FOR CHILLER 2 & 3**

MANUFACTURER: MARLEY      MODEL #8811  
SERIAL #88114-313-81

NO. OF FANS:      N/A

YEAR INSTALLED: 1984 (SPREADSHEET)

COMMENTS:      HAS BYPASS VALVE & TEMP. CONTROL

**BLDG 6003 COOLING TOWER FOR CHILLER 1**

MANUFACTURER: MARLEY      SERIAL #8619-4-627-73

NO. OF FANS:      N/A

YEAR INSTALLED: 1984 (SPREADSHEET)

**CHILLER FIELD SURVEY NOTES**

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JOB 3002.000 FT. SILL

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/13/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 730**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. L 83 H 13856**CHILLER TEST**

	kW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	<u>640kW 800 TON</u>	<u>821</u>	<u>821</u>	<u>460</u>	<u>460</u>	
TEST READINGS						
1	<u>564</u>	<u>747</u>	<u>802</u>	<u>469</u>	<u>470</u>	
2	<u>563</u>	<u>746</u>	<u>802</u>	/	/	
3	<u>562</u>	<u>746</u>	<u>801</u>			
4	<u>561</u>	<u>745</u>	<u>799</u>			
5	<u>561</u>		<u>804</u>			
6	<u>563</u>		<u>802</u>			
7	<u>565</u>		<u>803</u>			
8	<u>565</u>		<u>802</u>			
9	<u>565</u>		<u>802</u>			
10	<u>564</u>		<u>799</u>			
TEST READINGS	kVA	KVAR	P.FACTOR (%)			
	<u>632</u>	<u>287</u>				

(MIDDLE)

	CHILLED WATER PUMP #1		CONDENSER WATER PUMP #2		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	<u>460</u>	<u>475</u>	<u>220</u>	<u>199</u>	<u>230</u>	<u>197</u>
VOLTAGE - PHASE B	<u>460</u>	<u>477</u>	<u>220</u>	<u>202</u>	<u>230</u>	<u>200</u>
AMPS - PHASE A	<u>179</u>	<u>145</u>	<u>118</u>	<u>106.6</u>	<u>71.4</u>	<u>70.5</u>
AMPS - PHASE B	<u>179</u>	<u>150</u>	<u>118</u>	<u>108</u>	<u>71.4</u>	<u>71</u>
KW	/	<u>91</u>	/	<u>37.2</u>	/	<u>23</u>
KVAR		<u>80</u>		<u>5.8</u>		<u>9</u>
KVA		<u>120.9</u>		<u>37.6</u>		<u>25</u>
POWER FACTOR (%)						<u>93</u>

OUTDOOR AIR TEMP. (DEG F)	<u>85</u>	OUTDOOR HUMIDITY (%RH)	<u>61</u>	
TIME OF TESTING				

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/13/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SOURCE BLDG 730**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. L 83H 13 856**CHILLER TEST**

	kW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING						
TEST READINGS						
1						
2			OTHER PAGE			
3						
4						
5						
6						
7						
8						
9						
10						
TEST READINGS	kVA	KVAR	P.FACTOR (%)			

	CHILLED WATER PUMP #2		CONDENSER WATER PUMP #3		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	460	477	200	199		
VOLTAGE - PHASE B	460	475	200	197		
AMPS - PHASE A	179	148	90	86.1		
AMPS - PHASE B	179	146	90	82.6		
kW		93		25.4		
KVAR		79		14.4		
KVA		122		29.1		
POWER FACTOR (%)						

OUTDOOR AIR TEMP. (DEG F)		OUTDOOR HUMIDITY (%RH)	
TIME OF TESTING			

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/13/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 730**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. 283413856

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>53</u>	<u>38</u>	<u>N/A</u>	<u>85</u>	<u>1336</u>	<u>2378</u>
TEST READINGS						
1	<u>61.1</u>	<u>50.2</u>	<u>95.4</u>	<u>79</u>	<u>1334</u>	<u>3010</u>
2	<u>61.0</u>	<u>50.0</u>	<u>95.5</u>	<u>78.9</u>	<u>1334</u>	<u>2983</u>
3	<u>61.0</u>	<u>50.1</u>	<u>95.4</u>	<u>78.9</u>	<u>1354</u>	<u>3010</u>
4	<u>61.0</u>	<u>50.0</u>	<u>95.4</u>	<u>79.0</u>	<u>1364</u>	<u>3024</u>
5	<u>61.0</u>	<u>50.0</u>	<u>95.4</u>	<u>79.0</u>	<u>1354</u>	<u>3024</u>
6	<u>60.9</u>	<u>49.9</u>	<u>95.4</u>	<u>78.9</u>	<u>1384</u>	<u>3038</u>
7	<u>60.7</u>	<u>49.8</u>	<u>95.5</u>	<u>78.9</u>	<u>1384</u>	<u>3038</u>
8	<u>60.7</u>	<u>49.8</u>	<u>95.4</u>	<u>78.9</u>	<u>1374</u>	<u>3024</u>
9	<u>60.7</u>	<u>49.8</u>	<u>95.4</u>	<u>78.9</u>	<u>1384</u>	<u>2997</u>
10	<u>60.5</u>	<u>49.7</u>	<u>95.4</u>	<u>78.9</u>	<u>1374</u>	<u>3024</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	<u>47</u>	<u>38</u>	<u>13.5</u>	<u>8</u>	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	<u>250</u>	FT. HD.		FT. HD.	
TEST READINGS					
	<u>55</u>	<u>195</u>	<u>0</u>	<u>19</u>	

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JOB 3002,000 FT. SILL

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/13/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 730**CHILLER SURVEY FORM**CHILLER NO.: 3 (NORTH)  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. L80A06559**CHILLER TEST**

	kW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	32070N	367	367	480	480	
TEST READINGS						
1	214	285	313	461	465	
2	215	286	/	/	/	
3	215	286				
4	214	286				
5	214	286				
6	214	287				
7	215	286				
8	215	286				
9	214	286				
10	214	286				
TEST READINGS	kVA	KVAR	P.FACTOR (%)			
	240	108				

	(CENTER OF 3)		(EAST)			
	CHILLED WATER PUMP #2	CONDENSER WATER PUMP #1	COOLING TOWER			
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A		200	220	198.6		
VOLTAGE - PHASE B		198	220	202		
AMPS - PHASE A		63.5	118	101.7		
AMPS - PHASE B		62.9	118	104		
kW		20.2		35.7		
KVAR		9.1		5.8		
kVA		22.1		36.4		
POWER FACTOR (%)		91				

OUTDOOR AIR TEMP. (DEG F)	85	OUTDOOR HUMIDITY (%RH)	61	
TIME OF TESTING				

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/13/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 730**CHILLER SURVEY FORM**CHILLER NO.: 3 (NORTH)  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. 480406559

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING						
TEST READINGS						
1	57.6	43.0	84.9	75.5	471	990
2	57.6	43.1	84.8	75.4	474	986
3	57.7	43.0	84.8	75.4	474	982
4	57.7	43.0	84.8	75.4	474	986
5	57.6	43.0	84.8	75.4	474	982
6	57.6	43.0	84.8	75.5	474	978
7	57.6	43.0	84.8	75.3	471	978
8	57.6	43.0	84.8	75.3	471	986
9	57.6	42.9	84.8	75.3	471	986
10	57.7	43.0	84.8	75.3	471	978

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	54	48	21	13	

	#2 (CENTER)		#1 (EAST)		
	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING		FT. HD.		FT. HD.	
TEST READINGS					
	19	60.5	-1	20	

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CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE BLDG 914**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. L89J03103

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>58</u>	<u>45</u>			<u>800</u>	<u>950</u>
TEST READINGS						
1	<u>50.8</u>	<u>46.5</u>	<u>94.0</u>	<u>50.8</u>	<u>712</u>	<u>1156</u>
2	<u>50.9</u>	<u>46.5</u>	<u>94.0</u>	<u>50.9</u>	<u>723</u>	<u>1248</u>
3	<u>50.9</u>	<u>46.4</u>	<u>94.0</u>	<u>50.9</u>	<u>727</u>	<u>1217</u>
4	<u>50.8</u>	<u>46.4</u>	<u>93.9</u>	<u>50.8</u>	<u>734</u>	<u>1223</u>
5	<u>50.8</u>	<u>46.4</u>	<u>93.9</u>	<u>50.8</u>	<u>727</u>	<u>1180</u>
6	<u>50.9</u>	<u>46.4</u>	<u>93.9</u>	<u>50.9</u>	<u>727</u>	<u>1174</u>
7	<u>50.7</u>	<u>46.5</u>	<u>93.8</u>	<u>50.7</u>	<u>727</u>	<u>1052</u>
8	<u>50.9</u>	<u>46.5</u>	<u>93.8</u>	<u>50.9</u>	<u>723</u>	<u>984</u>
9	<u>50.8</u>	<u>46.4</u>	<u>93.8</u>	<u>50.8</u>	<u>730</u>	<u>978</u>
10	<u>50.7</u>	<u>46.4</u>	<u>93.8</u>	<u>50.7</u>	<u>730</u>	<u>978</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	<u>55</u>	<u>45</u>	<u>16</u>	<u>10</u>	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING		<u>70 FT. HD.</u>		<u>41 FT. HD.</u>	
TEST READINGS					
	<u>16.5</u>	<u>60</u>	<u>2.6</u>	<u>19</u>	

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/14/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 914**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. L89J03103**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	241kW 400TON	339	339	460	460	
TEST READINGS						
1	174	234	245	473	473	
2	163	/	/	/	/	
3	163					
4	162					
5	163					
6	162					
7	161					
8	160					
9	161					
10	161					
TEST READINGS	KVA	KVAR	P.FACTOR (%)			
	193	102				

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER FAN #2	
	RATED	TESTED	RATED	TESTED	RATED	TESTED *
VOLTAGE - PHASE A	460	472	460	476	460	477
VOLTAGE - PHASE B	460	472	460	475	460	476
AMPS - PHASE A	48	41.3	19	14.6	15	12.9
AMPS - PHASE B	48	41.3	19	14.2	15	11.8
KW	/	29.8	/	9.4		8.6
KVAR		15.7		7.7		5.9
KVA				12.2		10.5
POWER FACTOR (%)				77.4		82.3

\* HIGH SPEED

OUTDOOR AIR TEMP. (DEG F)	99	OUTDOOR HUMIDITY (%RH)	28	
TIME OF TESTING	15:05			

NOTE: CURRENT LIMIT SET AT 90%.

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SCALE BLDG 2812**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: CARRIERMODEL: 19DG6667CP  
SERIAL NO. 7543 24336

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>61</u>	<u>40</u>	<u>95</u>	<u>85</u>	<u>416</u>	<u>1092</u>
TEST READINGS						
1	<u>49.7</u>	<u>41.8</u>	<u>86.1</u>	<u>81.2</u>	<u>522</u>	<u>1337</u>
2	<u>49.7</u>	<u>41.8</u>	<u>86.1</u>	<u>81.2</u>	<u>542</u>	<u>1337</u>
3	<u>49.7</u>	<u>41.8</u>		<u>81.4</u>	<u>545</u>	<u>1326</u>
4	<u>49.6</u>	<u>41.8</u>		<u>81.3</u>	<u>584</u>	<u>1332</u>
5	<u>49.6</u>	<u>41.7</u>		<u>81.2</u>	<u>440</u>	<u>1342</u>
6	<u>49.6</u>	<u>41.7</u>			<u>496</u>	<u>1359</u>
7	<u>49.7</u>	<u>41.7</u>			<u>507</u>	<u>1359</u>
8	<u>49.7</u>	<u>41.7</u>			<u>553</u>	<u>1365</u>
9	<u>49.7</u>	<u>41.7</u>			<u>555</u>	<u>1354</u>
10	<u>49.7</u>	<u>41.8</u>	<u>86.2</u>		<u>562</u>	<u>1337</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING	$\Delta P = 3.5 \text{ PSI (MAX)}$		$\Delta P = 7.8 \text{ PSI (MAX)}$		
TEST READINGS					
	<del>N/A</del>	<del>44.5</del>	13.5	6	
	NO TAP	44.5			

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	<u>41 PSI OR</u>	<u>95 FT. HD.</u>	<u>24 PSI OR</u>	<u>55 FT. HD.</u>	
TEST READINGS					
	<u>41.5</u>	<u>79.5</u>	<u>-1.5</u>	<u>18</u>	

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

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SCALE BLDG 2812**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: CARRIERMODEL: 19DG6667CP  
SERIAL NO. 754324336**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	372TON	410	410	480	480	
TEST READINGS						
1	144.6	219	203	482	482	
2	144.3					
3	142.7					
4						
5						
6						
7						
8						
9						
10						
TEST READINGS	kVA	KVAR	P.FACTOR (%)			
	175.6	100.5	81.3			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	460	484	460	482	N/A	483
VOLTAGE - PHASE B	460	482	460	484		481
AMPS - PHASE A	27	23.2	31.5	26.2		18.6
AMPS - PHASE B	27	22.8	31.5	27.6		18.6
KW		14.4		17.8		11.8
KVAR		13.0		13.6		10.4
KVA		19.4		22.4		15.6
POWER FACTOR (%)		74.2		79.5		75.1

OUTDOOR AIR TEMP. (DEG F)	82.7	OUTDOOR HUMIDITY (%RH)	68.5	
TIME OF TESTING				

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CEL DATE 9/11/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE B L D G 3442**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: TRANEMODEL: CVHE-063F-AQ-  
SERIAL NO. 2PC2453CEIC11DEEC000000045Z1AC  
PL 4533-6519-01

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	60	45		85	1126	1975
TEST READINGS						
1	54.6	45.2	89.7	79.4	1130	1882
2	54.5	45.2			1145	1882
3	54.5	45.2			1140	1912
4	54.5	45.2			1130	1902
5	54.5	45.2			1140	1892
6	54.6	45.2			1120	1902
7	54.6	45.3			1130	1902
8	54.5	45.2			1135	1912
9	54.5	45.1			1155	1902
10	54.5	45.0			1145	1892

15sec.  
INTERVAL

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)
DESIGN RATING				
TEST READINGS				
	45.6	36.4	11.8	5.4

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)
DESIGN RATING	140	FT. HD.	50	FT. HD.
TEST READINGS				
	26	84	-NO TAPS-	

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CEL

DATE 9/11/90

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE BLOG 3442

## **CHILLER SURVEY FORM**

CHILLER NO.: 1

MODEL: \_\_\_\_\_

MANUFACTURER: TRANE

SERIAL NO. L88K04614

### **CHILLER TEST**

CHILLER TEST						
	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	360 KW @ 600T	502	502	460	460	
TEST READINGS						
1	299	403	421	480	480	} 15 SE INTER
2	297	/	/	/	/	
3	298					
4	298					
5	298					
6	297					
7	298					
8	298					
9	298					
10	297					
TEST READINGS	KVA	KVAR	P.FACTOR (%)			
	343	170.9				

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	460	482	460	481		NOT ACCESSABLE
VOLTAGE - PHASE B	460	481	460	481		
AMPS - PHASE A	73	63.5	52	42.1	15 HP	
AMPS - PHASE B	73	62.5	52	41.1	each,	
KW	/	44	/	24.0	total	
KVAR	/	29.7	/	25.3	of	
KVA	/	51.9	/	34.7	4 fans	
POWER FACTOR (%)	/		/			

OUTDOOR AIR TEMP. (DEG F)

80

OUTDOOR HUMIDITY (%RH)

57

TIME OF TESTING

12:10

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JOB 3002.000

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY LEL DATE 9/11/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLOG 3442**CHILLER SURVEY FORM**CHILLER NO.: 2  
MANUFACTURER: TRANEMODEL: AS CHILLER 1  
SERIAL NO. Same except -6518-01  
LB8KO 4613**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	360 kW @ 600T	502	502	460	460	
TEST READINGS						
1	310	416	440	480	480	
2	311					
3	311					
4	308					
5	310					
6	311					
7	309					
8	309					
9	310					
10	310					
TEST READINGS	KVA	KVAR	P.FACTOR (%)			
	357	177				

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	460	482	460	482		
VOLTAGE - PHASE B	460	480	460	480		
AMPS - PHASE A	73	63.8	52	35.3	see	
AMPS - PHASE B	73	63.0	52	34.3	chiller	
KW		43.8		22.1	I	
KVAR		29.1		19.2		
KVA		52.4		29.1		
POWER FACTOR (%)						

OUTDOOR AIR TEMP. (DEG F)	88.4	OUTDOOR HUMIDITY (%RH)	37.0
TIME OF TESTING	2:45		

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CEL DATE 9/11/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 3442**CHILLER SURVEY FORM**CHILLER NO.: 2  
MANUFACTURER: TRANEMODEL: SAMEASCHR1  
SERIAL NO. LB8104613

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>60</u>	<u>45</u>		<u>85</u>	<u>1126</u>	<u>1975</u>
TEST READINGS						
1	<u>55.5</u>	<u>45.4</u>	<u>85.6</u>	<u>78.7</u>	<u>1244</u>	<u>2182</u>
2	<u>55.5</u>	<u>45.4</u>			<u>1244</u>	<u>2091</u>
3	<u>55.5</u>	<u>45.4</u>	<u>86.5</u>	<u>79.1</u>	<u>1215</u>	<u>2079</u>
4	<u>55.5</u>	<u>45.3</u>			<u>1195</u>	<u>2103</u>
5	<u>55.4</u>	<u>45.3</u>	<u>86.2</u>	<u>78.8</u>	<u>1205</u>	<u>2151</u>
6	<u>55.4</u>	<u>45.4</u>			<u>1205</u>	<u>2247</u>
7	<u>55.4</u>	<u>45.4</u>			<u>1215</u>	<u>2282</u>
8	<u>55.5</u>	<u>45.4</u>			<u>1195</u>	<u>2318</u>
9	<u>55.5</u>	<u>45.4</u>			<u>1225</u>	<u>2306</u>
10	<u>55.5</u>	<u>45.4</u>			<u>1225</u>	<u>2294</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	<u>46.7</u>	<u>39.6</u>	<u>10.5</u>	<u>6.4</u>	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	<u>140</u>	FT. HD.	<u>50</u>	FT. HD.	
TEST READINGS					
	<u>29</u>	<u>83</u>	<u>30</u>	<u>84</u>	

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JOB 3002.000 FT. SILL  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALCULATED BY JW DATE 9/18/91  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
 SCALE BLDG 4701

### CHILLER SURVEY FORM

CHILLER NO.: 1  
 MANUFACTURER: CARRIER

MODEL: 19DG6138CN  
 SERIAL NO. 73-07-19401

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>53</u>	<u>43</u>	<u>95</u>	<u>85</u>	<u>1320</u>	<u>1650</u>
TEST READINGS						
1	<u>41.9</u>	<u>48.2</u>	<u>88.0</u>	<u>80.2</u>	<u>543</u>	<u>785</u>
2	<u>42.1</u>	<u>47.8</u>	<u>87.4</u>	<u>79.1</u>	<u>530</u>	<u>778</u>
3	<u>42.0</u>	<u>47.8</u>	<u>88.2</u>	<u>80.2</u>	<u>530</u>	<u>778</u>
4	<u>42.0</u>	<u>47.8</u>	<u>88.3</u>	<u>80.4</u>	<u>548</u>	<u>770</u>
5	<u>42.0</u>	<u>47.9</u>	<u>88.3</u>	<u>80.4</u>	<u>543</u>	<u>770</u>
6	<u>42.1</u>	<u>47.9</u>	<u>87.8</u>	<u>80.1</u>	<u>522</u>	<u>770</u>
7	<u>42.0</u>	<u>47.8</u>	<u>88.0</u>	<u>79.8</u>	<u>513</u>	<u>763</u>
8	<u>41.8</u>	<u>47.5</u>	<u>88.2</u>	<u>80.1</u>	<u>529</u>	<u>732</u>
9	<u>41.5</u>	<u>47.3</u>	<u>88.1</u>	<u>80.3</u>	<u>569</u>	<u>748</u>
10	<u>42.0</u>	<u>47.9</u>	<u>88.2</u>	<u>80.3</u>	<u>526</u>	<u>759</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING	<u><math>\Delta P = 10 \text{ PSI (MAX)}</math></u>		<u><math>\Delta P = 8.7 \text{ PSI (MAX)}</math></u>		
TEST READINGS					
	<u>2667.5</u>	<u>76</u>	<u>CLOGGED GAUGE</u>	<u>11</u>	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	<u>100 FT. HD.</u>		<u>22.5 PSI OK</u>		<u>52 FT. HD.</u>
TEST READINGS					
	<u>42.5</u>	<u>75</u>	<u>-7</u>	<u>19</u>	

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JOB 3002.000 FT. SILL

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/18/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 4701**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: CARRIERMODEL: 19DG6138CN  
SERIAL NO. 73-07-19401**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	<u>305TON</u>	<u>378</u>	<u>378</u>	<u>460</u>	<u>460</u>	
TEST READINGS						
1	<u>169.2</u>	<u>207</u>	<u>221</u>	<u>482</u>	<u>484</u>	
2	<u>169.5</u>	<u>205</u>	<u>220</u>			
3	<u>169.8</u>	<u>208</u>	<u>220</u>			
4	<u>170.5</u>	<u>209</u>	<u>220</u>			
5	<u>169.3</u>	<u>208</u>	<u>220</u>			
6	<u>169.6</u>	<u>206</u>	<u>220</u>			
7	<u>169.5</u>	<u>208</u>	<u>220</u>			
8	<u>169.3</u>	<u>209</u>	<u>220</u>			
9	<u>169.9</u>	<u>208</u>	<u>221</u>			
10	<u>170.3</u>	<u>208</u>	<u>221</u>			
TEST READINGS	KVA	KVAR	P.FACTOR (%)			
	<u>178</u>	<u>54</u>	<u>95.3</u>			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER <u>WEST</u>	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	<u>440</u>	<u>484</u>	<u>440</u>	<u>489</u>	<u>440</u>	<u>489</u>
VOLTAGE - PHASE B	<u>440</u>	<u>487</u>	<u>440</u>	<u>492</u>	<u>440</u>	<u>492</u>
AMPS - PHASE A	<u>60.7</u>	<u>50.0</u>	<u>38</u>	<u>32.0</u>	<u>19.2</u>	<u>15.8</u>
AMPS - PHASE B	<u>60.7</u>	<u>51.6</u>	<u>38</u>	<u>34.7</u>	<u>19.2</u>	<u>17.5</u>
KW		<u>33.1</u>		<u>24.8</u>		<u>10.5</u>
KVAR		<u>28.4</u>		<u>14.2</u>		<u>9.8</u>
KVA		<u>43.6</u>		<u>28.4</u>		<u>14.3</u>
POWER FACTOR (%)		<u>76.1</u>		<u>86.7</u>		<u>73.5</u>

OUTDOOR AIR TEMP. (DEG F)	<u>79.7</u>	OUTDOOR HUMIDITY (%RH)	<u>85.4</u>
TIME OF TESTING			

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JOB 3002.000 FT. SILL  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
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 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
 SCALE BLDG 4701

### CHILLER SURVEY FORM

CHILLER NO.: 2  
 MANUFACTURER: CARRIER

MODEL: 19DG6158CN  
 SERIAL NO. 731019729

#### CHILLER TEST

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	<u>305TON</u>	<u>378</u>	<u>378</u>	<u>460</u>	<u>460</u>	
TEST READINGS						
1	<u>113</u>	<u>159</u>	<u>159</u>	<u>485</u>	<u>488</u>	
2	<u>110</u>	<u>156</u>	<u>158</u>	/	/	
3	<u>116</u>	<u>153</u>	<u>157</u>			
4	<u>94</u>	<u>144</u>	<u>160</u>			
5	<u>94</u>	<u>114</u>	<u>115</u>			
6	<u>94</u>	<u>120</u>	<u>112</u>			
7	<u>113</u>	<u>151</u>	<u>155</u>			
8	<u>112</u>	<u>147.7</u>	<u>150</u>			
9	<u>96</u>	<u>112</u>	<u>113</u>			
10	<u>112</u>	<u>156</u>	<u>148</u>			
TEST READINGS	KVA	KVAR	P.FACTOR (%)			
	<u>97</u>	<u>24</u>	<u>97</u>			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER (EAST)	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	<u>440</u>	<u>OFF</u>	<u>440</u>	<u>OFF</u>	<u>460</u>	<u>488</u>
VOLTAGE - PHASE B	<u>440</u>		<u>440</u>		<u>460</u>	<u>485</u>
AMPS - PHASE A	<u>60.7</u>		<u>38</u>		<u>24.6</u>	<u>18.1</u>
AMPS - PHASE B	<u>60.7</u>		<u>38</u>		<u>24.6</u>	<u>18.3</u>
KW	/		/			<u>12.0</u>
KVAR						<u>9.9</u>
KVA						<u>15.6</u>
POWER FACTOR (%)						<u>77.0</u>

OUTDOOR AIR TEMP. (DEG F)	<u>84.6</u>	OUTDOOR HUMIDITY (%RH)	<u>69.3</u>	
TIME OF TESTING				

NOTE: THIS CHILLER LOADS & UNLOADS EVERY 20 SEC.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/18/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 4701**CHILLER SURVEY FORM**CHILLER NO.: 2  
MANUFACTURER: CARRIERMODEL: 19D G6158CN  
SERIAL NO. 7310 19729

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>53</u>	<u>43</u>	<u>95</u>	<u>85</u>	<u>1320</u>	<u>1650</u>
TEST READINGS						
1	<u>48.6</u>	<u>43.3</u>	<u>86.3</u>	<u>80.8</u>	<u>660</u>	<u>875</u>
2	<u>48.4</u>	<u>43.6</u>	<u>86.8</u>	<u>80.8</u>	<u>709</u>	<u>886</u>
3	<u>48.5</u>	<u>43.8</u>	<u>86.8</u>	<u>80.6</u>	<u>697</u>	<u>897</u>
4	<u>48.4</u>	<u>43.6</u>	<u>86.0</u>	<u>80.7</u>	<u>691</u>	<u>908</u>
5	<u>48.5</u>	<u>42.9</u>	<u>85.9</u>	<u>80.7</u>	<u>666</u>	<u>886</u>
6	<u>48.3</u>	<u>43.2</u>	<u>86.8</u>	<u>80.8</u>	<u>660</u>	<u>880</u>
7	<u>48.4</u>	<u>43.5</u>	<u>86.8</u>	<u>80.8</u>	<u>685</u>	<u>891</u>
8	<u>48.5</u>	<u>43.8</u>	<u>86.5</u>	<u>80.9</u>	<u>727</u>	<u>891</u>
9	<u>48.5</u>	<u>43.6</u>	<u>86.1</u>	<u>80.9</u>	<u>727</u>	<u>897</u>
10	<u>48.4</u>	<u>43.2</u>	<u>86.7</u>	<u>80.8</u>	<u>678</u>	<u>902</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING	$\Delta P = 10 \text{ PSI (MAX)}$		$\Delta P = 8.7 \text{ PSI (MAX)}$		
TEST READINGS					
	67.0	76.5	GAUGE CLOGGED		11

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	<del>100</del> FT. HD.		FT. HD.		
TEST READINGS					
	OFF		OFF		

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

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SCALE BLDG 5676**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: CARRIERMODEL: 19DG5132CB  
SERIAL NO. 7342 20665

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>52</u>	<u>44</u>	<u>95</u>	<u>85</u>	<u>540</u>	<u>525</u>
TEST READINGS						
1	<u>57.8</u>	<u>53.6</u>	<u>89.3</u>	<u>80.5</u>	<u>465</u>	<u>563</u>
2	<u>57.2</u>	<u>53.2</u>	<u>89.3</u>	<u>80.5</u>	<u>465</u>	<u>563</u>
3	<u>57.1</u>	<u>53.1</u>	<u>89.5</u>	<u>80.7</u>	<u>465</u>	<u>567</u>
4	<u>57.0</u>	<u>53.0</u>	<u>89.7</u>	<u>80.8</u>	<u>461</u>	<u>571</u>
5	<u>56.4</u>	<u>52.5</u>	<u>89.7</u>	<u>80.9</u>	<u>465</u>	<u>563</u>
6	<u>56.2</u>	<u>52.1</u>	<u>89.7</u>	<u>80.8</u>	<u>465</u>	<u>563</u>
7	<u>55.8</u>	<u>51.7</u>	<u>89.7</u>	<u>80.8</u>	<u>486</u>	<u>563</u>
8	<u>55.8</u>	<u>51.6</u>	<u>89.9</u>	<u>80.9</u>	<u>465</u>	<u>563</u>
9	<u>55.3</u>	<u>51.4</u>	<u>89.9</u>	<u>81.4</u>	<u>470</u>	<u>567</u>
10	<u>55.5</u>	<u>51.4</u>	<u>89.9</u>	<u>81.9</u>	<u>474</u>	<u>571</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING	$\Delta P = 10.8 \text{ PSI (MAX)}$		$\Delta P = 6.5 \text{ PSI (MAX)}$		
TEST READINGS					
	24.0	38.5	NO GAUGES OR TAPS		

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	FT. HD.		FT. HD.		
TEST READINGS					
	22.5	57.5	0	9.6	

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/17/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 5676**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: CARRIERMODEL: 19DG5132CB  
SERIAL NO. 73 42 20665**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	155 kW	211	211	460	460	
TEST READINGS						
1	118.4	166	165	478	478	
2	118.7	/	/	/	/	
3	118.8					
4	119.1					
5	119.0					
6	118.3					
7	118.7					
8	121.0					
9	121.9					
10	120.9					
TEST READINGS	kVA	KVAR	P.FACTOR (%)			
	139.4	72.3	85.6			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	460	460	460	NOT	460	480
VOLTAGE - PHASE B	460	460	460	ACCESSIBLE	460	480
AMPS - PHASE A	13.5	13.0	11		10.5	8.6
AMPS - PHASE B	13.5	13.3	11		10.5	9.4
KW	/	N/A	/			5.6
KVAR						5.5
kVA						7.9
POWER FACTOR (%)						70.7

OUTDOOR AIR TEMP. (DEG F)	77.5	OUTDOOR HUMIDITY (%RH)	98.8 (RAINING)
TIME OF TESTING	9:00 AM		

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

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CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 5678**CHILLER SURVEY FORM**CHILLER NO.: Z1  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. L82J06486**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	142kW 1907AN	195	195	460	460	
TEST READINGS						
1	108	150	150	479	477	
2	107					
3	104					
4	105					
5	107					
6	104					
7	106					
8	107					
9	103					
10	106					
TEST READINGS						
	kVA	kVAR	P.FACTOR (%)			
	124.0	69.7	83.5			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	460	478	460	477	N/A	480
VOLTAGE - PHASE B	460	478	460	478		478
AMPS - PHASE A	25.1	20.5	11	10.2		8.7
AMPS - PHASE B	25.1	20.0	11	10.0		9.6
KW		13.8		6.0		5.4
KVAR		9.3		5.8		5.5
KVA		16.6		8.4		7.8
POWER FACTOR (%)		83%		71.4		71.4

OUTDOOR AIR TEMP. (DEG F)	79.1	OUTDOOR HUMIDITY (%RH)	73.6	
TIME OF TESTING				

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JOB 3002.000 FT. SILL

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 9/17/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 5678**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. L82J06486

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>53</u>	<u>45.0</u>	<u>85</u>	<u>95</u>	<u>546</u>	<u>570</u>
TEST READINGS						
1	<u>58.9</u>	<u>54.4</u>	<u>78.6</u>	<u>86.1</u>	<u>864</u>	<u>670</u>
2	<u>58.4</u>	<u>54.1</u>	<u>79.5</u>	<u>86.7</u>	<u>918</u>	<u>673</u>
3	<u>58.0</u>	<u>53.7</u>	<u>79.6</u>	<u>86.7</u>	<u>918</u>	<u>673</u>
4	<u>58.0</u>	<u>53.6</u>	<u>79.9</u>	<u>86.9</u>	<u>914</u>	<u>676</u>
5	<u>57.7</u>	<u>53.5</u>	<u>80.0</u>	<u>86.6</u>	<u>931</u>	<u>676</u>
6	<u>57.6</u>	<u>53.4</u>	<u>80.0</u>	<u>86.8</u>	<u>927</u>	<u>676</u>
7	<u>57.2</u>	<u>53.2</u>	<u>80.0</u>	<u>86.8</u>	<u>885</u>	<u>676</u>
8	<u>57.2</u>	<u>53.2</u>	<u>80.0</u>	<u>86.6</u>	<u>859</u>	<u>682</u>
9	<u>57.0</u>	<u>53.0</u>	<u>79.8</u>	<u>86.5</u>	<u>804</u>	<u>686</u>
10	<u>56.9</u>	<u>53.1</u>	<u>79.8</u>	<u>86.4</u>	<u>900</u>	<u>689</u>

AVG = 57.7AVG = 53.5AVG = 892AVG = 677

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING	<u><math>\Delta P = 9.1 \text{ PSI (MAX)}</math></u>		<u><math>\Delta P = 6.07 \text{ PSI (MAX)}</math></u>		
TEST READINGS					
	<u>35.5</u>	<u>27</u>	<u>12</u>	<u>6</u>	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	FT. HD.		FT. HD.		
TEST READINGS					
	<u>14</u>	<u>51</u>	<u>0</u>	<u>13.5</u>	

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JOB 9802.016, FT. SILL

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CEL DATE 9/16/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLOG 5900**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: CARRIERMODEL: 19D46968CQ  
SERIAL NO. 771826211**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	<u>NA</u>	<u>476</u>	<u>476</u>	<u>460</u>	<u>460</u>	
TEST READINGS						
1	<u>323</u>	<u>440</u>	<u>451</u>	<u>466</u>	<u>466</u>	
2	<u>325</u>	<u>440</u>	<u>452</u>			
3	<u>324</u>	<u>442</u>	<u>453</u>			
4	<u>325</u>	<u>441</u>	<u>452</u>			
5	<u>325</u>	<u>442</u>	<u>452</u>			
6	<u>323</u>	<u>441</u>	<u>449</u>			
7	<u>324</u>	<u>441</u>	<u>449</u>			
8	<u>324</u>	<u>441</u>	<u>451</u>			
9	<u>325</u>	<u>442</u>	<u>451</u>			
10	<u>325</u>	<u>443</u>	<u>453</u>			
TEST READINGS	KVA	KVAR	P.FACTOR (%)			
	<u>348</u>	<u>153.4</u>	<u>89.5</u>			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	<u>460</u>	<u>473</u>	<u>460</u>	<u>473</u>	<u>NO</u>	<u>473</u>
VOLTAGE - PHASE B	<u>460</u>	<u>474</u>	<u>460</u>	<u>473</u>	<u>NAME</u>	<u>27.5</u>
AMPS - PHASE A	<u>62.5</u>	<u>58.8</u>	<u>32</u>	<u>26.6</u>	<u>PLATE</u>	<u>27.2</u>
AMPS - PHASE B	<u>62.5</u>	<u>60</u>	<u>32</u>	<u>25.9</u>		<u>19.2</u>
KW	<u>NA</u>	<u>39.5</u>	<u>NA</u>	<u>17.6</u>		<u>11.5</u>
KVAR		<u>29.2</u>		<u>12.4</u>		<u>22.0</u>
KVA		<u>49.1</u>		<u>21.5</u>		<u>85.6</u>
POWER FACTOR (%)		<u>80.4</u>		<u>81.8</u>		

OUTDOOR AIR TEMP. (DEG F)	<u>96.8</u>	OUTDOOR HUMIDITY (%RH)	<u>32.3</u>
TIME OF TESTING	<u>14:40</u>		

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JOB 9802.016, FT. SILL

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CELDATE 9/16/90

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE 3204 5900**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: CARRIERMODEL: 19 DG 696 8 C Q  
SERIAL NO. 77 18 242.11

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	53.7	40	95	85	700	1200
TEST READINGS	78°F W.B.					
1	58.6	45.7	103.7	93.8	688	1588
2	58.6	45.8		94.8	699	1594
3	58.6	46.0		95.2	677	1588
4	58.9	46.1		95.8	682	1581
5	59.0	46.2		95.9	682	
6	59.1	46.3		96.5	671	
7	59.1	46.4		96.6	666	
8	59.1	46.4		96.7	671	
9	59.2	46.5	107.3	96.9	660	
10	59.3	46.4		97.0	666	

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	112	100	12	6	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	190	FT. HD.	61	FT. HD.	
TEST READINGS					
	36	108	-4	22	

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CEL DATE 9/15/90

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SCALE BLDG 5900**CHILLER SURVEY FORM**CHILLER NO.: 2  
MANUFACTURER: WESTINGHOUSEMODEL: Tc 416B  
SERIAL NO. DY 95**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	315 KW @ 400 TON	438	438	460	460	
TEST READINGS						
1	308	420	417	470	470	
2	309	421	/	/	/	
3	309	420				
4	310	420				
5	309	420				
6	311		418			
7	309	420	420			
8	308	422	/			
9	310	422				
10	310	420				
TEST READINGS	KVA	KVAR	P.FACTOR (%)			
	340	145	90.6			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	460	474	460	474	No	474
VOLTAGE - PHASE B	460	473	460	474		474
AMPS - PHASE A	69	53.8	39.8	35.3	DATA	21.4
AMPS - PHASE B	69	53.4	39.8	35.9		21.6
KW	/	38.7	/	23.0	/	14.2
KVAR	/	20.9	/	18.3		10.1
KVA	/	44.2	/	29.4		17.6
POWER FACTOR (%)	/	88.0	/	78.2		82.3

OUTDOOR AIR TEMP. (DEG F)	83.8	OUTDOOR HUMIDITY (%RH)	44.7
TIME OF TESTING			

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DATE \_\_\_\_\_

SCALE BLPG 5900**CHILLER SURVEY FORM**

CHILLER NO.:

2

MANUFACTURER:

WESTINGHOUSE

MODEL:

TC416B

SERIAL NO.

DY95

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>53.7</u>	<u>40</u>	<u>85</u>	<u>95</u>	<u>700</u>	<u>1200</u>
TEST READINGS						
1	<u>52.5</u>	<u>41.7</u>	<u>93</u>	<u>100</u>	<u>721</u>	<u>1455</u>
2	<u>52.5</u>	<u>41.7</u>			<u>727</u>	<u>1449</u>
3	<u>52.5</u>	<u>41.7</u>			<u>727</u>	<u>1462</u>
4	<u>52.5</u>	<u>41.7</u>			<u>727</u>	<u>1437</u>
5	<u>52.5</u>	<u>41.7</u>			<u>733</u>	<u>1419</u>
6	<u>52.5</u>	<u>41.7</u>			<u>727</u>	<u>1431</u>
7	<u>52.6</u>	<u>41.8</u>			<u>727</u>	<u>1425</u>
8	<u>52.6</u>	<u>41.8</u>			<u>733</u>	<u>1437</u>
9	<u>52.5</u>	<u>41.7</u>			<u>733</u>	<u>1425</u>
10	<u>52.5</u>	<u>41.7</u>	<u>93</u>	<u>100</u>	<u>727</u>	<u>1437</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	<u>105</u>	<u>101</u>	<u>17</u>	<u>NO DATA</u>	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING					
TEST READINGS					
	<u>35</u>	<u>107</u>	<u>-1</u>	<u>28</u>	

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SEAL BLDG 5900**CHILLER SURVEY FORM**CHILLER NO.: 3MANUFACTURER: CARRIERMODEL: 19DK7687CNSERIAL NO. 850536514**CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	263KW @ 372Tons	346	346	480	480	
TEST READINGS						
1	231	330	324	470	469	
2	232	329	327			
3	231	330	325			
4	232	329	325			
5	231	329	324			
6	230	328	323			
7	230	326	323			
8	231	326	323			
9	230	327	323			
10	230	326	322	470	469	
TEST READINGS						
	KVA	KVAR	P.FACTOR (%)			
	129.2	265	87.3			
	265	129				

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	460	474	460	474	No	470
VOLTAGE - PHASE B	460	473	460	474		470
AMPS - PHASE A	75	62.5	38	36.3	DATA	22.9
AMPS - PHASE B	75	61.0	38	35.1		23.2
KW		41.9		24.1		14.0
KVAR		27.9		16.9		12.8
KVA		50.3		29.1		18.9
POWER FACTOR (%)				82.4		73.7

OUTDOOR AIR TEMP. (DEG F)	89.7	OUTDOOR HUMIDITY (%RH)	45	
TIME OF TESTING	10:10			

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SCALE BLDG 5900**CHILLER SURVEY FORM**CHILLER NO.: 3  
MANUFACTURER: CARRIERMODEL: 19DK7687CN  
SERIAL NO. 850536514

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>52.8</u>	<u>40</u>	<u>95</u>	<u>85</u>	<u>700</u>	<u>1200</u>
TEST READINGS						
1	<u>54.6</u>	<u>45.2</u>	<u>93.6</u>	<u>86.2</u>	<u>736</u>	<u>1337</u>
2	<u>54.7</u>	<u>45.2</u>	<u>93.5</u>	<u>86.2</u>	<u>732</u>	<u>1332</u>
3	<u>54.5</u>	<u>45.3</u>	<u>93.5</u>	<u>86.1</u>	<u>736</u>	<u>1348</u>
4	<u>54.5</u>	<u>45.3</u>	<u>93.5</u>	<u>86.1</u>	<u>727</u>	<u>1351</u>
5	<u>54.4</u>	<u>45.1</u>	<u>93.5</u>	<u>86.1</u>	<u>719</u>	<u>1345</u>
6	<u>54.4</u>	<u>45.1</u>	<u>93.7</u>	<u>86.3</u>	<u>710</u>	<u>1345</u>
7	<u>54.4</u>	<u>45.0</u>	<u>93.7</u>	<u>86.3</u>	<u>706</u>	<u>1351</u>
8	<u>54.2</u>	<u>45.0</u>	<u>93.7</u>	<u>86.3</u>	<u>702</u>	<u>1345</u>
9	<u>54.3</u>	<u>45.0</u>	<u>93.8</u>	<u>86.3</u>	<u>710</u>	<u>1339</u>
10	<u>54.3</u>	<u>45.0</u>	<u>93.7</u>	<u>86.3</u>	<u>697</u>	<u>1345</u>

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	<u>101</u>	<u>94</u>	<u>19</u>	<u>4</u>	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	<u>190</u>	FT. HD.	<u>75</u>	FT. HD.	
TEST READINGS					
	<u>34</u>	<u>100</u>	<u>-4</u>	<u>23.5</u>	

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SERIAL NO. BLDG 5900**CHILLER SURVEY FORM**CHILLER NO.: 4MODEL: PEH076MANUFACTURER: Mc QUAYSERIAL NO. 5RF0300700

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	52.1	40	85	94	890	1350
TEST READINGS	78°FWB					
1	54.0	43.4	81.4	91.5	844	1584
2	54.0	43.4	81.4	91.6	850	1610
3	54.0	43.5	81.4	91.6	856	1627
4	54.1	43.5	81.4	91.5	856	1601
5	54.0	43.5	81.4	91.5	856	1635
6	54.0	43.5	81.4	91.5	856	1635
7	54.0	43.5	81.3	91.4	850	1652
8	53.9	43.4	81.5	91.5	862	1592
9	53.7	43.3	81.5	91.5	856	1592
10	53.8	43.4	81.5	91.5	856	1575

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	100	94	15	6.6	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING		FT. HD.		FT. HD.	
TEST READINGS					
	35	99	-2	32	

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SCALE BLDG 5900

## **CHILLER SURVEY FORM**

CHILLER NO.: 4  
MANUFACTURER: M. C. QUAY

MODEL: PEH076  
SERIAL NO. 5RF0300700

### **CHILLER TEST**

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	<u>396 KW @ 4500W</u>	<u>501</u>	<u>501</u>	<u>480</u>	<u>480</u>	
TEST READINGS						
1	<u>345</u>	<u>481</u>	<u>470</u>	<u>465</u>	<u>465</u>	
2	<u>344</u>	<u>481</u>	<u>471</u>			
3	<u>344</u>	<u>479</u>	<u>472</u>			
4	<u>345</u>	<u>481</u>	<u>473</u>			
5	<u>345</u>	<u>478</u>	<u>470</u>			
6	<u>346</u>	<u>482</u>	<u>472</u>			
7	<u>346</u>	<u>482</u>	<u>472</u>			
8	<u>344</u>	<u>478</u>	<u>468</u>			
9	<u>343</u>	<u>479</u>	<u>473</u>			
10	<u>345</u>	<u>481</u>	<u>470</u>			
TEST READINGS	KVA	KVAR	P.FACTOR (%)			
	<u>386</u>	<u>174.2</u>	<u>89</u>			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED *
VOLTAGE - PHASE A	<u>460</u>	<u>463</u>	<u>460</u>	<u>464</u>	<u>460</u>	<u>468</u>
VOLTAGE - PHASE B	<u>460</u>	<u>463</u>	<u>460</u>	<u>463</u>	<u>460</u>	<u>467</u>
AMPS - PHASE A	<u>93</u>	<u>83.8</u>	<u>52</u>	<u>43.6</u>	<u>30/14</u>	<u>NOT</u>
AMPS - PHASE B	<u>93</u>	<u>80.8</u>	<u>52</u>	<u>42.4</u>	<u>30/14</u>	<u>ENOUGH</u>
KW		<u>54.1</u>		<u>26.6</u>		<u>SPACE TO</u>
KVAR		<u>38.5</u>		<u>23.0</u>		<u>TAKE</u>
KVA		<u>66.3</u>		<u>35.3</u>		<u>MEASUREMENT.</u>
POWER FACTOR (%)		<u>81.4</u>		<u>75.6</u>		

\* HIGH SPEED

OUTDOOR AIR TEMP. (DEG F)	<u>85.1</u>	OUTDOOR HUMIDITY (%RH)	<u>46.4</u>
TIME OF TESTING	<u>11:05</u>		

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SCALE BLDG 5900**CHILLER SURVEY FORM**CHILLER NO.: 5  
MANUFACTURER: CARRIERMODEL: 190K78404CQ  
SERIAL NO. 871539461

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	53.6	40	94	85	700	1200
TEST READINGS						
1	53.3	42.9	92.4	80.5	676	1024
2	53.3	42.9	92.4	80.4	676	1031
3	53.3	42.8	92.4	80.4	650	1031
4	53.3	42.9	92.4	80.4	642	1038
5	53.3	42.7	92.4	80.4	655	1024
6	53.3	42.7	92.4	80.4	616	1024
7	53.3	42.7	92.4	80.4	646	1024
8	53.3	42.7	92.4	80.4	603	1024
9	53.3	42.7	92.5	80.6	603	1024
10	53.3	42.7	92.6	80.6	638	1045

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	107	98	17	12	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING	192 FT. HD.		75 FT. HD.		
TEST READINGS					
	36	112	0	33	

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SCALE BLDG 5900**CHILLER SURVEY FORM**CHILLER NO.: 5  
MANUFACTURER: CARRIERMODEL: 190K 784 04CQ  
SERIAL NO. 8715 39461**CHILLER TEST**

	kW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	270kW@400T	399	399	460	460	
TEST READINGS						
1	236	360	357	468	470	
2	235	/	/	/	/	
3	238					
4	238					
5	238					
6	238					
7	238					
8	238					
9	238					
10	238					
TEST READINGS	kVA	kVAR	P.F. FACTOR (%)			
	292	175	80			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED *
VOLTAGE - PHASE A	460	470	460	470	460	471
VOLTAGE - PHASE B	460	471	460	471	460	472
AMPS - PHASE A	77	66.5	38	31.4	24/8	24.2
AMPS - PHASE B	77	67.4	38	33.0	24/8	24.6
kW	/	43.6	/	22.0	/	17.1
kVAR		33.0		14.8		10.2
kVA		54.7		26.5		19.8
POWER FACTOR (%)		72.8				85.7

\* HIGH SPEED

OUTDOOR AIR TEMP. (DEG F)	95.5	OUTDOOR HUMIDITY (%RH)	27.9
TIME OF TESTING	5:02		

17:05

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JOB 3 002, 000  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALCULATED BY CEL DATE 9 / 12 / 90  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
 SCALE B L D G 6003

### CHILLER SURVEY FORM

CHILLER NO.: 1  
 MANUFACTURER: TRANE

MODEL: CV11A-DAF-HH-09LH1AYA  
 SERIAL NO. LB1B21810

15A 1A51600

#### CHILLER TEST

	KW	AMPS PHASE A	AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	NA	~445	~445	460	460	
TEST READINGS						
1						
2	— CHILLER WAS NOT OPERATIONAL —					
3						
4						
5						
6						
7						
8						
9						
10						
TEST READINGS	KVA	KVAR	P.FACTOR (%)			

	CHILLED WATER PUMP		CONDENSER WATER PUMP 3		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A			460	466		
VOLTAGE - PHASE B	OFF		460	467		
AMPS - PHASE A			37	29		
AMPS - PHASE B	NO		37	29		
KW	DATA			17.4		
KVAR				15.3		
KVA				23.2		
POWER FACTOR (%)						

OUTDOOR AIR TEMP. (DEG F)		OUTDOOR HUMIDITY (%RH)	
TIME OF TESTING			

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SCALE BLDG 6003**CHILLER SURVEY FORM**CHILLER NO.: 1  
MANUFACTURER: TRANEMODEL: \_\_\_\_\_  
SERIAL NO. L81B21810

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	58	42	95	85	645	1130
TEST READINGS						
1	Chiller not operational				685*	1208
2						1213
3						1228
4						1218
5						1223
6						1223
7						1223
8						1208
9						1213
10						1203

**\* GRISWOLD FLOW DEVICE**

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING		FT. HD.		FT. HD.	
TEST READINGS					
	OFF		3.0	37	

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SCALE BLDG 6003

## **CHILLER SURVEY FORM**

CHILLER NO.: 2  
MANUFACTURER: TRANE

MODEL: CVE-0456-A4-2K8237ICE3C130EFC000  
SERIAL NO. L86D37156

### **CHILLER TEST**

	kW		AMPS PHASE A		AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	<u>.60</u>		<u>~ 445</u>		<u>~ 445</u>	<u>460</u>	<u>460</u>	
TEST READINGS	1-10	11-20	1-10	11-20				
1	<u>57</u>	<u>57</u>	<u>119</u>	<u>117</u>		<u>460</u>	<u>467</u>	} 15 second intervals on readings
2	<u>56</u>	<u>57</u>	<u>132</u>	<u>118</u>				
3	<u>128</u>	<u>149</u>	<u>200</u>	<u>214</u>				
4	<u>145</u>	<u>137</u>	<u>208</u>	<u>215</u>				
5	<u>132</u>	<u>134</u>	<u>203</u>	<u>204</u>				
6	<u>129</u>	<u>132</u>	<u>205</u>	<u>204</u>				
7	<u>132</u>	<u>136</u>	<u>204</u>	<u>202</u>				
8	<u>136</u>	<u>136</u>	<u>203</u>	<u>208</u>				
9	<u>134</u>	<u>43</u>	<u>204</u>	<u>121</u>				
10	<u>120</u>		<u>200</u>					
TEST READINGS	kVA		kVAR		P.FACTOR (%)			
	<u>147</u>		<u>80</u>					
	kW = <u>120</u>							

### **CHILLER SURGE**

	CHILLED WATER PUMP 2		CONDENSER WATER PUMP 2		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	<u>460</u>	<u>470</u>	<u>460</u>	<u>462</u>		
VOLTAGE - PHASE B	<u>460</u>	<u>470</u>	<u>460</u>	<u>462</u>		
AMPS - PHASE A	<u>62.5</u>	<u>43.0</u>	<u>37</u>	<u>30.7</u>	<u>N</u>	<u>A</u>
AMPS - PHASE B	<u>62.5</u>	<u>45.8</u>	<u>37</u>	<u>31.9</u>		
KW		<u>26.6</u>		<u>19</u>		
KVAR		<u>23.1</u>		<u>15.8</u>		
KVA		<u>35.3</u>		<u>24.7</u>		
POWER FACTOR (%)						

OUTDOOR AIR TEMP. (DEG F)	<u>73</u>	OUTDOOR HUMIDITY (%RH)	<u>87</u>	<u>RAINING</u>
TIME OF TESTING				

# **E M C ENGINEERS, INC.**

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JOB 3002.000, FT. SILL

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CEL DATE 9/12/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 6003

## **CHILLER SURVEY FORM**

CHILLER NO.: 2  
MANUFACTURER: TRANE

MODEL: \_\_\_\_\_  
SERIAL NO. L86D37156

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>58</u>	<u>42</u>	<u>95</u>	<u>85</u>	<u>540</u>	<u>1130</u>
TEST READINGS	1-10	11-20	1-10	11-20		
1	<u>56.6</u>	<u>56.6</u>	<u>47.0</u>	<u>45.6</u>	<u>84</u>	<u>82</u>
2			<u>50.2</u>	<u>47.7</u>		<u>540*</u>
3			<u>51.9</u>	<u>48.9</u>		<u>1096</u>
4			<u>52.2</u>	<u>51.5</u>		<u>1110</u>
5			<u>50.4</u>	<u>51.4</u>		<u>1106</u>
6			<u>47.8</u>	<u>48.3</u>		<u>1106</u>
7			<u>46.0</u>	<u>46.7</u>		<u>1110</u>
8			<u>45.6</u>	<u>45.8</u>		<u>1101</u>
9			<u>45.4</u>	<u>45.7</u>		<u>1091</u>
10			<u>45.2</u>	<u>45.6</u>		<u>1101</u>
						<u>1110</u>
						<u>1125</u>

\* NO GOOD METERING LOCATIONS, CONSTANT FLOW DEVICE (GRISWOLD) SET @ 540 GPM

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)
DESIGN RATING				
TEST READINGS				
	<u>40</u>	<u>32</u>	<u>19.2</u>	<u>10.5</u>

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)
DESIGN RATING		FT. HD.		FT. HD.
TEST READINGS				
	<u>6</u>	<u>70.5</u>	<u>NO READING FITTING</u>	<u>23</u>

CLOGGED

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JOB 3002.000, FT. SILL

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CEL DATE 9/12/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLDG 6003

## **CHILLER SURVEY FORM**

CHILLER NO.: 3  
MANUFACTURER: TRANE

MODEL: \_\_\_\_\_  
SERIAL NO. L86037155

	CHILLED WATER RETURN (DEG F)	CHILLED WATER SUPPLY (DEG F)	CONDENSER WATER RETURN (DEG F)	CONDENSER WATER SUPPLY (DEG F)	CHILLED WATER FLOW (GPM)	CONDENSER WATER FLOW (GPM)
DESIGN RATING	<u>58</u>	<u>42</u>	<u>95</u>	<u>85</u>	<u>540</u>	<u>1130</u>
TEST READINGS		<u>1ST</u> <u>2ND</u>				
1	<u>57</u>	<u>45.1</u> <u>44.9</u>	<u>85</u>	<u>80</u>	<u>540*</u>	<u>1348</u>
2		<u>45.0</u> <u>44.9</u>				<u>1376</u>
3		<u>44.9</u> <u>45.0</u>				<u>1449</u>
4		<u>47.6</u> <u>49.0</u>				<u>1486</u>
5		<u>50.5</u> <u>51.5</u>				<u>1468</u>
6		<u>52.4</u> <u>52.7</u>				<u>1404</u>
7		<u>52.8</u> <u>52.9</u>				<u>1394</u>
8		<u>50.8</u> <u>50.4</u>				<u>1385</u>
9		<u>47.6</u> <u>47.1</u>				<u>1376</u>
10		<u>45.7</u> <u>45.5</u>				<u>1356</u>

↑ SURGING ↓

\* NO GOOD METER SPOT. HAS FLOW  
DEVICE (GRISWOLD) SET @ 540 GPM.

	EVAPORATOR PRESSURE RETURN (PSIG)	EVAPORATOR PRESSURE SUPPLY (PSIG)	CONDENSER PRESSURE RETURN (PSIG)	CONDENSER PRESSURE SUPPLY (PSIG)	
DESIGN RATING					
TEST READINGS					
	<u>34.4</u>	<u>31.7</u>	<u>10.5</u>	<u>18.5</u>	

	CHW PUMP PRESSURE IN (PSIG)	CHW PUMP PRESSURE OUT (PSIG)	CNW PUMP PRESSURE IN (PSIG)	CNW PUMP PRESSURE OUT (PSIG)	
DESIGN RATING		FT. HD.		FT. HD.	
TEST READINGS					
	<u>15.0</u>	<u>72.0</u>	<u>-13</u>	<u>22</u>	
			<u>SUCTION</u>		

15 sec.  
INTERV.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY CEL DATE 9/12/90

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE BLOG 6003

## **CHILLER SURVEY FORM**

CHILLER NO.: 3  
MANUFACTURER: TRANE

MODEL: CVHE-0456-AH-2KB237ICE3CBDEF  
SERIAL NO. LB6D37155

20000000021J00

### **CHILLER TEST**

	KW		AMPS PHASE A		AMPS PHASE B	VOLTAGE PHASE A	VOLTAGE PHASE B	
DESIGN RATING	<u>.60</u>		<u>~ 445</u>		<u>~ 445</u>	<u>460</u>	<u>460</u>	
TEST READINGS	1-10	11-20	1-10	11-20				
1	<u>121</u>	<u>127</u>	<u>196</u>	<u>193</u>		<u>465</u>	<u>465</u>	
2	<u>124</u>	<u>121</u>	<u>196</u>	<u>192</u>				
3	<u>120</u>	<u>112</u>	<u>183</u>	<u>184</u>				
4	<u>115</u>	<u>108</u>	<u>187</u>	<u>180</u>				
5	<u>92</u>	<u>72</u>	<u>97</u>	<u>160</u>				
6	<u>54</u>	<u>43</u>	<u>114</u>	<u>120</u>				
7	<u>57</u>		<u>122</u>					
8	<u>64</u>		<u>120</u>					
9	<u>125</u>		<u>190</u>					
10	<u>122</u>		<u>205</u>					
TEST READINGS	KVA		KVAR		P.FACTOR (%)			
	<u>124</u>		<u>140</u>		<u>80</u>			

	CHILLED WATER PUMP		CONDENSER WATER PUMP		COOLING TOWER	
	RATED	TESTED	RATED	TESTED	RATED	TESTED
VOLTAGE - PHASE A	<u>460</u>	<u>466</u>	<u>460</u>	<u>465</u>	<u>460</u>	<u>465</u>
VOLTAGE - PHASE B	<u>460</u>	<u>465</u>	<u>460</u>	<u>466</u>	<u>460</u>	<u>456</u>
AMPS - PHASE A	<u>62.5</u>	<u>45.0</u>	<u>37</u>	<u>33.6</u>	<u>63</u>	<u>54.7</u>
AMPS - PHASE B	<u>62.5</u>	<u>47.6</u>	<u>37</u>	<u>28.0</u>	<u>63</u>	<u>57.2</u>
KW	<u>28</u>	<u>19.0</u>	<u>36.3</u>			
KVAR	<u>22.5</u>	<u>16.5</u>	<u>25.5</u>			
KVA	<u>36.4</u>	<u>25.1</u>	<u>44.3</u>			
POWER FACTOR (%)	<u>—</u>	<u>—</u>	<u>—</u>			

OUTDOOR AIR TEMP. (DEG F)	<u>73</u>	OUTDOOR HUMIDITY (%RH)	<u>87</u>	<u>RAINING</u>
TIME OF TESTING				

**APPENDIX F**

**FIELD SURVEY NOTES**  
**BOILER-RELATED EQUIPMENT**

**BOILER FIELD SURVEY NOTES**

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JOB 3002.000 Ft. Sill Central Plant  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALCULATED BY KC DATE 2/9/91  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

### BOILER SURVEY FORM

BOILER # 1

BOILER MFG.: Kewanee LOCATION: 730  
BOILER TYPE: STEAM [X] 11 PSI HOT WATER [ ] \_\_\_\_\_ DEG. F SET POINT  
MODEL NO. 76286-KX  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 7,750,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS [X] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR [X] OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_  
CONTROL MFG.: PEABODY-GORDON-PIATT. GP 301  
(HONEYWELL) R41411089

#### STACK TEST:

TEST 1

OAT = 62°F  
OARH = 38% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	*	*	*	*
TEMP (F)				
CO				
% EFF				

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

#### COMMENTS:

BOILER #1, 2, 3 ARE FOR WINTER USE  
BOILER #4 IS FOR SUMMER USE.

\* CANNOT TEST - SOOTED INDICATED INCOMPLETE COMBUSTION  
HAS HAD PAST TROUBLES.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
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CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

**BOILER SURVEY FORM**

BOILER # 2

BOILER MFG.: KLEWANE LOCATION: 730  
BOILER TYPE: STEAM [X] 11 PSI HOT WATER [ ] \_\_\_\_\_ DEG. F SET POINT  
MODEL NO. 76286-KX  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 7,750,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS [X] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR [X] OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: PEABODY-GORDON-PIATT. GP 301  
(HONEYWELL) R41441089

**STACK TEST:**

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O2	<u>4</u>	<u>3</u>	<u>0.4</u>	<u>0.7</u>
TEMP (F)	<u>192</u>	<u>295</u>	<u>416</u>	<u>421</u>
CO	<u>0</u>	<u>11.8</u>	<u>1.5%</u>	<u>0.2%</u>
% EFF	<u>86</u>	<u>84.5</u>	<u>82.4</u>	<u>81.4</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

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JOB 3002.000 Ft. Sill Central Plant

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY KC DATE 2/9/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**

BOILER #3

BOILER MFG.: KEWANEE LOCATION: 730  
BOILER TYPE: STEAM [X] 11 PSI HOT WATER [ ] DEG. F SET POINT  
MODEL NO. 76286-KX  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 7,750,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS [X] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR [X] OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: PEABODY-GORDON-PIATT. GP 301  
(HONEYWELL) R414L1089

**STACK TEST:**

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O2	0.3	5.5	5.6	5.8
TEMP (F)	265	345	358	362
CO	0	0.35%	0.27.	0.127.
% EFF	85.6	82.4	82	81.7

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALCULATED BY RC DATE 2/9/81  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

### BOILER SURVEY FORM

BOILER # 4

BOILER MFG.: Kewanee LOCATION: 730  
BOILER TYPE: STEAM ☒ 11 PSI HOT WATER ☐ \_\_\_\_\_ DEG. F SET POINT  
MODEL NO. 7L280-43-06  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 2,658,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL ☐ # \_\_\_\_\_ GAS ☒ ELECTRIC ☐ OTHER ☐

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR ☒ OPEN FLAME ☐  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: PEABODY GORDON-PATT 060794-000  
091126

#### STACK TEST:

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>	12.5			6.3
TEMP (F)	222			371
CO	0			0
% EFF	85			81.5

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				
TEMP (F)				
CO				
% EFF				

#### COMMENTS:

FOR SUMMER USE.

# BOILER SURVEY FORM

BLDG. NO 730

DATE 2/12/91

OPERATOR NAME MIKE APOKA

NUMBER OF BOILER(S) 4

NUMBER OF PUMPS HEATING. \*

	DAILY OPERATION	NIGHT WEEKEND & HOLIDAY OPERATION
NO. OF BOILER ON-LINE <u>3</u>	ALL 3 DURING WINTER  1 DURING SUMMER	ALL 3 DURING WINTER  1 DURING SUMMER
NO. OF PUMP ON-LINE <u>2 Condensate</u>		

BOILER SHUTDOWN BY OUTSIDE AIR TEMP X NO  
       YES        TEMP

MONITOR X DAILY        WEEKLY

## COMMENTS

BLG 730 SUPPLYS BLDGS 700, 707 AND  
840 WITH HOT WATER FOR HTG  
\* 1 CIRC. PUMP FOR 3 OUTLINE  
BLDGS 3 COND PUMPS FOR STEAM  
BOILERS

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JOB 3002.000 Ft. Sill Central Plant

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/11/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**

BOILER #1

BOILER MFG.: BURNHAM LOCATION: 914  
BOILER TYPE: STEAM ☒ 10-12 PSI HOT WATER ☐ DEG. F SET POINT  
MODEL NO. 2580699 PP-510  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 1,612,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL ☐ # \_\_\_\_\_ GAS ☒ ELECTRIC ☐ OTHER ☐

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR ☒ OPEN FLAME ☐  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: HONEYWELL R4795**STACK TEST:**

TEST 1

OAT: 59°F  
DARH: 40% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	7.3			3.9
TEMP (F)	359			387
CO	9 PPM			4 PPM
% EFF	80.9			82

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

STM BOILER SERVE DOMESTIC HW CONVERTER FOR 914.  
CONTROL BY PRESSURE; CUT IN @ 2.5 PSIG AND CUT OFF @ 12 PSIG.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALCULATED BY JW DATE 2/11/91  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 2

BOILER MFG.: RAYPAK LOCATION: 914  
BOILER TYPE: STEAM [ ] PSI HOT WATER [x] 180 DEG. F SET POINT  
MODEL NO. EA 200 1TB  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 1,600,000  
MAX BTUH INPUT: 2,000,000  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS [x] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR [ ] OPEN FLAME [x]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: \_\_\_\_\_  
\_\_\_\_\_

**STACK TEST:**

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O2				<u>8.4</u>
TEMP (F)				<u>454</u>
CO				<u>14 PPM</u>
% EFF				<u>77.4</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

COMMENTS: HOT WATER / ATM  
NEW CONTROLS NEEDED

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JOB 3002.000 Ft. Sill Central Plant  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALCULATED BY JW DATE 2/11/91  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

**BOILER SURVEY FORM**

BOILER MFG.: AMERICAN STANDARD LOCATION: Boiler # 3  
BOILER TYPE: STEAM [ ] PSI HOT WATER [X] 914 DEG. F SET POINT  
MODEL NO. G-1013 140  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 1,920,000  
MAX BTUH INPUT: 2,400,000  
BOILER FUEL: OIL [ ] # GAS [X] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR [ ] OPEN FLAME [X]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: HONEYWELL M904EY99D56

**STACK TEST:**

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				5.9
TEMP (F)				500
CO				26 PPM
% EFF				77.9

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				
TEMP (F)				
CO				
% EFF				

COMMENTS: NEW CONTROLS NEEDED  
HOT WATER / ATM

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALCULATED BY JW DATE 2/11/91  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

**BOILER SURVEY FORM**Boiler #4

BOILER MFG.: AMERICAN STANDARD LOCATION: 914  
BOILER TYPE: STEAM [ ] PSI HOT WATER [x] 140 DEG. F SET POINT  
MODEL NO. G-1015 160  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 1,920,000  
MAX BTUH INPUT: 2,400,000  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS [x] ELECTRIC [ ] OTHER [ ]

**BURNER MFG.:**

MODEL NO. \_\_\_\_\_

BURNER TYPE

FORCE AIR [ ]

OPEN FLAME [x]

SEASONAL SWITCH OVER:

SUMMER  
WINTERTO  
TO

CONTROL MFG.:

HONEYWELL M904EY99D56**STACK TEST:**

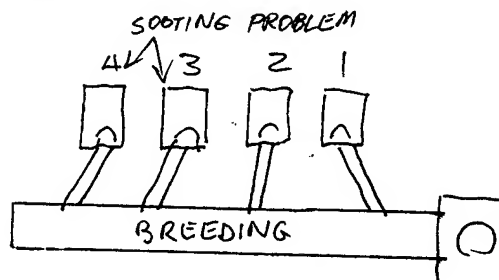
TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				<u>11.1</u>
TEMP (F)				<u>460</u>
CO				<u>0</u>
% EFF				<u>74.4</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				
TEMP (F)				
CO				
% EFF				

COMMENTS: NEW CONTROLS NEEDED  
HOT WATER/ATM  
STACK SOOTING



# BOILER SURVEY FORM.

BLDG. NO 914

DATE 2/12/91

OPERATOR NAME MIKE APOKA

NUMBER OF BOILER(S) 4

NUMBER OF PUMPS HEATING. 2

	DAILY OPERATION	NIGHT WEEKEND & HOLIDAY OPERATION
NO. OF BOILER ON-LINE  2		
NO. OF PUMP ON-LINE  2		

BOILER SHUTDOWN BY OUTSIDE AIR TEMP NO YES 65°F TEMP

MONITOR      DAILY X WEEKLY

## COMMENTS

1 HOT WATER BOILER USED FOR HTG DURING  
MILD WEATHER, 2 BOILERS FOR SEVERE WEATHER.  
1 STEAM BOILER ALL YEAR LONG FOR MAKING  
HOT WATER

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/11/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**Boiler # 1

BOILER MFG.: FEDERAL BOILER CO LOCATION: 2812  
BOILER TYPE: STEAM [✓] PSI HOT WATER [ ] DEG. F SET POINT  
MODEL NO. GS 3562 S#84137B  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 1,800,000  
MAX BTUH INPUT: 2,250,000  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS [✓] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR [✓] OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: HONEYWELL 139694B

**STACK TEST:**

TEST 1  
OAT = 63°F  
OARH = 35% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2				<u>8.7</u>
TEMP (F)				<u>380</u>
CO				<u>20 PPM</u>
% EFF				<u>79.7</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

COMMENTS: FOR DOMESTIC HW ONLY - SERVE 2811, MESS HALL.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/11/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 2BOILER MFG.: THERMO-PAKBOILER TYPE: STEAM [ ] \_\_\_\_\_ PSILOCATION: 2812HOT WATER [X] 190 DEG. F SET POINTMODEL NO. GW-5500XBOILER'S CAPACITY: MAX BTUH OUTPUT: 3,947,000MAX BTUH INPUT: 4,933,750

BOILER FUEL: OIL [ ] # \_\_\_\_\_

GAS [X] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_

MODEL NO. \_\_\_\_\_

BURNER TYPE FORCE AIR [ ] OPEN FLAME [X]SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_CONTROL MFG.: HONEYWELL RA 890F**STACK TEST:**

TEST 1

OAT = 63°FOARH = 35% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	<u>15.3</u>			<u>15.3/13.3</u>
TEMP (F)	<u>364</u>			<u>429</u>
CO	<u>12 PPM</u>			<u>18 PPM</u>
% EFF	<u>71.7</u>			<u>71.5</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

COMMENTS:

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CALCULATED BY JW DATE 2/11/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 3BOILER MFG.: THERMO-PAKBOILER TYPE: STEAM [ ] \_\_\_\_\_ PSILOCATION: 2812HOT WATER [X] 190 DEG. F SET POINTMODEL NO. GW-5500XBOILER'S CAPACITY: MAX BTUH OUTPUT: 3,947,000MAX BTUH INPUT: 4,933,750

BOILER FUEL: OIL [ ] # \_\_\_\_\_

GAS [ ] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_

MODEL NO. \_\_\_\_\_

BURNER TYPE \_\_\_\_\_ FORCE AIR [ ] \_\_\_\_\_ OPEN FLAME [X]

SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_CONTROL MFG.: HONEYWELL RA890F**STACK TEST:**

TEST 1

OAT 63°F  
OARH 35%RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	<u>14.3</u>			<u>10.8</u>
TEMP (F)	<u>375</u>			<u>472</u>
CO	<u>15 PPM</u>			<u>0</u>
% EFF	<u>72.4</u>			<u>74</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

# BOILER SURVEY FORM.

BLDG. NO 2812

DATE 2-12-91

OPERATOR NAME Jerry Wilson

NUMBER OF BOILER(S) (3) 2 Hot Water Boilers, 1 Steam

NUMBER OF PUMP(S) HEATING. (3) 2 Heating, 1 Boiler Feed

	DAILY OPERATION	NIGHT WEEKEND & HOLIDAY OPERATION.
NO. OF BOILER ON-LINE	3 DURING HEATING SEASON 1-365 DAYS A YEAR	24 HRS A DAY 7 DAYS A WEEK 1 LEAD BOILER, 1 LAG BOILER
NO. OF PUMP ON-LINE	3 DURING HEAT SEASON 1-365 DAYS A YEAR	

BOILER SHUTDOWN BY OUTSIDE AIR TEMP NO  
X YES 70°F TEMP

MONITOR X DAILY WEEKLY BLOW DOWN OF CONTROLS

## COMMENTS

1 Steam Boiler MAINTAINS DOMESTIC HOT WATER + DISHWASHER

HOT WATER FOR MESS. HALL

2 Hot Water Boilers MAINTAIN WATER TEMP. FOR

HEATING SYSTEM BY INSIDE, OUTSIDE TEMP. CONTROLLER

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY KC DATE 2/8/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**

BOILER MFG.: BIRCHFIELD LOCATION: Boiler #1  
BOILER TYPE: STEAM ☒ 100 PSI HOT WATER ☐ 4701 DEG. F SET POINT  
MODEL NO. FBH 578  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 1,100,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL ☐ # \_\_\_\_\_ GAS ☒ ELECTRIC ☐ OTHER ☐

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR ☒ OPEN FLAME ☐  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: HONEYWELL R41404089 2  
TYPE GP-301

**STACK TEST:**

TEST 1  
DATE = 66 °F  
OARH = 291 RH

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>	<u>5.2</u>	<u>4.2</u>	<u>4.9</u>	<u>4.7</u>
TEMP (F)	<u>434</u>	<u>475</u>	<u>481</u>	<u>486</u>
CO	<u>20</u>	<u>34</u>	<u>30</u>	<u>31</u>
% EFF	<u>80.3</u>	<u>78.9</u>	<u>78.9</u>	<u>79.2</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

- FUEL - AIR RATIO NOT SET IN PAST 5 YEARS.
- O<sub>2</sub>SAT NOT USED
- LOGS KEPT BUT VALUES FOR CO<sub>2</sub> & STACK TEMP. SIMPLY GUESSED
- OIL CAPABLE - NOT USED FOR YEARS.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY KC DATE 2/8/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER #2

BOILER MFG.: BIRCHFIELD LOCATION: 4701  
BOILER TYPE: STEAM ☒ 100 PSI HOT WATER ☐ \_\_\_\_\_ DEG. F SET POINT  
MODEL NO. FBH 578  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 1,100,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL ☐ # \_\_\_\_\_ GAS ☒ ELECTRIC ☐ OTHER ☐

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR ☒ OPEN FLAME ☐  
SEASONAL SWITCH OVER: SUMMER TO \_\_\_\_\_  
WINTER TO \_\_\_\_\_

CONTROL MFG.: HONEYWELL R41404089 2  
TYPE GP-301

**STACK TEST:**

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

- NOT OPERATING.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALCULATED BY EC DATE 2/8/91  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

### BOILER SURVEY FORM

BOILER MFG.: BIRCHFIELD LOCATION: 4701  
BOILER TYPE: STEAM 100 PSI HOT WATER [ ] 4701 DEG. F SET POINT  
MODEL NO. FBH 578  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 1,100,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS ☒ ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR ☒ OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: HONEYWELL GP-301 R 4140L1089 2

#### STACK TEST:

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O2	8.3	3.9	4.8	5.2
TEMP (F)	418	457	470	474
CO	19	37	37	35
% EFF	78.2	79.5	79.5	79.2

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

COMMENTS: SAME AS BOILER #1

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/8/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 1BOILER MFG.: AMERICAN STANDARDLOCATION: 5676BOILER TYPE: STEAM [ ] \_\_\_\_\_ PSIHOT WATER ☒ 158 DEG. F SET POINTMODEL NO. PFS15BOILER'S CAPACITY: MAX BTUH OUTPUT: 2,440,000MAX BTUH INPUT: 2,975,000

BOILER FUEL: OIL [ ] # \_\_\_\_\_

GAS ☒ ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_

MODEL NO. \_\_\_\_\_

BURNER TYPE FORCE AIR ☒ OPEN FLAME [ ]

SEASONAL SWITCH OVER: \_\_\_\_\_

SUMMER \_\_\_\_\_

WINTER \_\_\_\_\_

TO \_\_\_\_\_

TO \_\_\_\_\_

CONTROL MFG.: BURNHAMM# R10.9-GO-15**STACK TEST:**

TEST 1

OAT = 49°F  
OARH = 68% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	14.8			4.6
TEMP (F)	308			607
CO2 %	3.4			9.2
% EFF	74 %			75.1 %

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

DUAL PIPE SYSTEM

SLOTTED LEVER ARM FUEL, AIR ADJUST = TYPE 1

NOT SET WITH ORSAT BY OEM

3 WAY VALVE OSA

HWS RESET TEMP,

SERVES DORMS, THEREFORE HEAT RECOVERY CANDIDATE

- 2 HWP.

- DOMESTIC HOT WATER BOILER

	TEMP.	O2	CO2
BL #1	4.2	436	9.4
BL #2	2.8	441	10.2

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY KC DATE 2/8/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 2BOILER MFG.: AMERICAN STANDARDBOILER TYPE: STEAM [ ] PSILOCATION: 5676HOT WATER ☒ 168 DEG. F SET POINTMODEL NO. PF 515BOILER'S CAPACITY: MAX BTUH OUTPUT: 2,440,000MAX BTUH INPUT: 2,975,000BOILER FUEL: OIL ☐ # \_\_\_\_\_GAS ☒ ELECTRIC ☐ OTHER ☐

BURNER MFG.: \_\_\_\_\_

MODEL NO. \_\_\_\_\_

BURNER TYPE FORCE AIR ☒ OPEN FLAME [ ]SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_CONTROL MFG.: BURNHAM M# R10.9-60-15**STACK TEST:**

TEST 1

OAT = 49°F  
DARH = 68% RH.

	LOW FIRE	50%	75%	HIGH FIRE
%O2	<u>11.8</u>			<u>5.0</u>
TEMP (F)	<u>453</u>			<u>740</u>
CO	<u>0.3%</u>			<u>0.2%</u>
% EFF	<u>72.9%</u>			<u>71.4%</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**SAME AS BOILER #1

# BOILER SURVEY FORM.

BLDG. NO. 5676

DATE \_\_\_\_\_

OPERATOR NAME Samir Guffin

NUMBER OF BOILER(S) 2

NUMBER OF PUMPS HEATING. 2

	DAILY OPERATION	NIGHT WEEKEND & HOLIDAY OPERATION.
NO. OF BOILER ON-LINE <u>2</u>		
NO. OF PUMP ON-LINE <u>1</u>		

BOILER SHUTDOWN BY OUTSIDE AIR TEMP ☒ NO ☐ YES \_\_\_\_\_ TEMP

MONITOR \_\_\_\_\_ DAILY ☒ WEEKLY

COMMENTS

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/8/91

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SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 1BOILER MFG.: BURNHAMBOILER TYPE: STEAM [ ] \_\_\_\_\_ PSILOCATION: 5678  
HOT WATER [X] 168 DEG. F SET POINTMODEL NO. PF-514BOILER'S CAPACITY: MAX BTUH OUTPUT: 2,272,000MAX BTUH INPUT: 2,779,000BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS ☒ ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_

MODEL NO. \_\_\_\_\_

BURNER TYPE FORCE AIR ☒ OPEN FLAME [ ]SEASONAL SWITCH OVER: SUMMER TO \_\_\_\_\_  
WINTER OCT. TO MAR.CONTROL MFG.: WEBSTER M# J2G-07-R4140-L.20**STACK TEST:**

TEST 1

OAT = 49 F  
OARH = 68% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	<u>17.5</u>			<u>15.4</u>
TEMP (F)	<u>310</u>			<u>430</u>
CO	<u>.137%</u>			<u>.132%</u>
% EFF	<u>74%</u>			<u>67.5%</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**SAME AS 5676HOT WATER BOILERS (DOMESTIC)BL #1 TEMP O2  
430 15.4 %BL #2 454 12 %4 HWP IN PARALLEL  
2 DTNP.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALCULATED BY KC DATE 2/8/91  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

**BOILER SURVEY FORM**Boiler #2

BOILER MFG.: BURNHAM LOCATION: 5678  
BOILER TYPE: STEAM [ ] PSI HOT WATER [X] 165 DEG. F SET POINT  
MODEL NO. PF-514  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 2,272,000  
MAX BTUH INPUT: 2,779,000  
BOILER FUEL: OIL [ ] # GAS [X] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE: FORCE AIR [X] OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER TO \_\_\_\_\_  
WINTER OCT TO MAR

CONTROL MFG.: WEBSTER MH J20-07-R4140-L.20

**STACK TEST:**

TEST 1

OAT = 49 F  
OAT = 68 % RH.

	LOW FIRE	50%	75%	HIGH FIRE
%O2	<u>15.5</u>			<u>12</u>
TEMP (F)	<u>286</u>			<u>454</u>
CO	<u>01.</u>			<u>01.</u>
% EFF	<u>76.6</u>			<u>73.3</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**SAME AS BOILER #1

## BOILER SURVEY FORM.

BLDG. NO. 5678

DATE 2-12-91

OPERATOR NAME SAMMIE GUFFIN

NUMBER OF BOILER(S) 2

NUMBER OF PUMP(S) HEATING. 5

	DAILY OPERATION	NIGHT WEEKEND & HOLIDAY OPERATION.
NO. OF BOILER ON-LINE 2		
NO. OF PUMP ON-LINE 4		

BOILER SHUTDOWN BY OUTSIDE AIR TEMP. X NO        YES        TEMP

MONITOR \_\_\_\_\_ DAILY ✓ WEEKLY

## COMMENTS

[illegible]

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/9/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 1

BOILER MFG.: INTERNATIONAL BOILER WORKS LOCATION: 5908  
BOILER TYPE: STEAM [ ] PSI HOT WATER ☒ 380 DEG. F SET POINT  
MODEL NO. 11633  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 10,000,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS ☒ ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR ☒ OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: BRISTOL

**STACK TEST:**

TEST 1

OAT = 60°F  
OARH = 45% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>	<u>6.1</u>	<u>5.9</u>	<u>5.6</u>	<u>7</u>
TEMP (F)	<u>558</u>	<u>595</u>	<u>660</u>	<u>702</u>
CO	<u>10 PPM</u>	<u>17 PPM</u>	<u>14 PPM</u>	<u>14 PPM</u>
% EFF	<u>76.3</u>	<u>75.2</u>	<u>73.7</u>	<u>70.9</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				
TEMP (F)				
CO				
% EFF				

COMMENTS: BOILER PANELS HAVE RECORDING O<sub>2</sub>, STACK TEMP., BUT ARE NOT CALIBRATED. PLANT HAS ORSAT USED IN SETTING FLUE GAS RATIO.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/9/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 2

BOILER MFG.: INTERNATIONAL BOILER WORKS LOCATION: 5900  
BOILER TYPE: STEAM [ ]        PSI HOT WATER [x] 380 DEG. F SET POINT  
MODEL NO. 11633  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 10,000,000  
MAX BTUH INPUT:         
BOILER FUEL: OIL [ ] #        GAS [ ] ELECTRIC [ ] OTHER [ ]

BURNER MFG.:         
MODEL NO.         
BURNER TYPE        FORCE AIR [x]        OPEN FLAME [ ]         
SEASONAL SWITCH OVER: SUMMER        TO         
WINTER        TO       

CONTROL MFG.: BRISTOL**STACK TEST:**

TEST 1

OAT = 60°F  
OARH = 45% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	6.6	1.4		5.0
TEMP (F)	500	590		690
CO	15 PPM	25 PPM		42 PPM
% EFF	77.5	78		73.2

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

COMMENTS: FIVE PUMPS IN PARALLEL SERVE ALL BOILERS

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JOB 3002.000 Ft. Sill Central Plant

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/9/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 3

BOILER MFG.: HERCULES BOILER CO. LOCATION: 5910  
BOILER TYPE: STEAM [ ] PSI HOT WATER ☒ 385 DEG. F SET POINT  
MODEL NO. 300  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 9,700,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS ☒ ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR ☒ OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: HONEYWELL**STACK TEST:**

TEST 1

OAT = 60°F  
OARH = 457.4H

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>	<u>10.9</u>	<u>5.2</u>	<u>4.7</u>	<u>5.5</u>
TEMP (F)	<u>303</u>	<u>400</u>	<u>405</u>	<u>434</u>
CO	<u>3 PPM</u>	<u>11 PPM</u>	<u>14 PPM</u>	<u>25 PPM</u>
% EFF	<u>80.7</u>	<u>81.2</u>	<u>81</u>	<u>80</u>

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				
TEMP (F)				
CO				
% EFF				

COMMENTS: DESIGN  $\Delta P \approx 75$  PSI

THE  $\Delta P$  HTHW CONTROL DOES NOT OPERATE,  
OPERATORS PUT PUMPS ON AND OFF LINE TO VARY FLOW  
AND CONTROL,

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JOB 3002.000 Ft. Sill Central Plant

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/9/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**

BOILER #4

BOILER MFG.: HERCULES BOILER LOCATION: 5900  
BOILER TYPE: STEAM [ ] PSI HOT WATER [☒] 385 DEG. F SET POINT  
MODEL NO. 300  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 9,700,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS [☒] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR [☒] OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: HONEYWELL

**STACK TEST:**

TEST 1

OAT = 60°F

OARH = 45% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	12.6	6.4	4.7	5.9
TEMP (F)	231	400	418	440
CO	2.95%	0.8%	0.2%	0.09%
% EFF	82.4	80.5	81	79.6

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

HTHWR TEMP. AT  $\approx 250^{\circ}\text{F}$   
(HTHWS IS VARIED FROM  $\approx 310^{\circ}\text{F}$  TO  $340^{\circ}\text{F}$  WITH OSA,

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/9/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER # 5

BOILER MFG.: INTERNATIONAL BOILER WORKS LOCATION: 5900  
BOILER TYPE: STEAM [ ] PSI HOT WATER ☒ 380 DEG. F SET POINT  
MODEL NO. TH12  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 8,000,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS ☒ ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. \_\_\_\_\_  
BURNER TYPE FORCE AIR ☒ OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER TO \_\_\_\_\_  
WINTER TO \_\_\_\_\_

CONTROL MFG.: N/A**STACK TEST:**

TEST 1

OAT = 60°FOARH = 45% RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	9.5	8.2	6.9	5.6
TEMP (F)	350	410	440	465
CO	55 PPM	24 PPM	16 PPM	17 PPM
% EFF	80.3	79.1	79	79.2

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/9/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER #6

BOILER MFG.: INTERNATIONAL BOILER WORKS LOCATION: 5900  
BOILER TYPE: STEAM [ ] PSI HOT WATER [X] 380 DEG. F SET POINT  
MODEL NO. TJW-C-10  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 11,200,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS [X] ELECTRIC [ ] OTHER [ ]

BURNER MFG.: \_\_\_\_\_  
MODEL NO. TJW-C-10  
BURNER TYPE FORCE AIR OPEN FLAME [ ]  
SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_

CONTROL MFG.: Fire eye TYPE 72 DIR1

**STACK TEST:**

TEST 1

OAT = 60°F  
OARH = 45% RH.

	LOW FIRE	50%	75%	HIGH FIRE
%O2	8.4	8.0	6.9	5.4
TEMP (F)	371	360	389	402
CO	0%	0%	0%	0%
% EFF	80	80.7	80.6	80.8

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

# BOILER SURVEY FORM.

BLDG. NO 5900

DATE 2-12-91

OPERATOR NAME Roger Coody

NUMBER OF BOILER(S) As Required 6

NUMBER OF PUMPS HEATING. As Required

	DAILY OPERATION	NIGHT WEEKEND & HOLIDAY OPERATION
NO. OF BOILER ON-LINE  2	AS Required by load	
NO. OF PUMP ON-LINE  6	AS Required by load	

BOILER SHUTDOWN BY OUTSIDE AIR TEMP ☒ NO ☐ YES TEMP

MONITOR ☐ DAILY ☐ WEEKLY

## COMMENTS

Boilers Are monitored Hourly Wintu  
operation Idle Boilers Heated by Trickle To  
MAINTAIN 1 Standby Boiler min

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JOB 3002.000 Ft. Sill Central Plant

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/11/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**Boiler #1

BOILER MFG.: KEWANEE BOILER CO LOCATION: 6003  
BOILER TYPE: STEAM 15 PSI HOT WATER [ ] \_\_\_\_\_ DEG. F SET POINT  
MODEL NO. L3S-350-G05  
BOILER'S CAPACITY: MAX BTUH OUTPUT: 11,716,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL [ ] # \_\_\_\_\_ GAS ☒ ELECTRIC [ ] OTHER [ ]

**BURNER MFG.:** \_\_\_\_\_

MODEL NO. \_\_\_\_\_

BURNER TYPE \_\_\_\_\_ FORCE AIR ☒ OPEN FLAME [ ] \_\_\_\_\_SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_CONTROL MFG.: GORDON - PIATT # GP 2840**STACK TEST:**

TEST 1

OAT = 60 °F  
OARH = 427 °RH

	LOW FIRE	50%	75%	HIGH FIRE
%O2	15.2	7.1	6.4	6.6
TEMP (F)	271	322	335	337
CO	0	0	0	0
% EFF	77.2	82.4	82.3	82.3

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

**COMMENTS:**

- LOW FIRE NEEDS ADJ. FOR LESS AIR
- SAFETY VALVES: DISTANCE TO DRIP PAN TOO GREAT,
- GOOD CONTROL
- SUMMER ONLY #3 RUN
- WINTER EITHER #1 OR #2 RUN

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JOB 3002.000 Ft. Sill Central Plant  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALCULATED BY JW DATE 2/4/91  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

**BOILER SURVEY FORM**

BOILER MFG.: YORK SHIPLEY - STEAM PAK LOCATION: BOILER #2  
BOILER TYPE: STEAM ☒ 30 PSI 6003 HOT WATER ☐ \_\_\_\_\_ DEG. F SET POINT  
MODEL NO. SPL-350-11 15  
BOILER'S CAPACITY: MAX BTUH OUTPUT: N/A 11,718,000  
MAX BTUH INPUT: \_\_\_\_\_  
BOILER FUEL: OIL ☐ # \_\_\_\_\_ GAS ☒ ELECTRIC ☐ OTHER ☐

**BURNER MFG.:** \_\_\_\_\_

MODEL NO. \_\_\_\_\_

BURNER TYPE FORCE AIR ☒ OPEN FLAME ☐SEASONAL SWITCH OVER: SUMMER TO \_\_\_\_\_  
WINTER TO \_\_\_\_\_CONTROL MFG.: HONEYWELL BC7000**STACK TEST:**

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>	10.4	13	12.7	11.9
TEMP (F)	250	263	290	303
CO	47	575	280 PPM	200 PPM
% EFF	82.9	80.6	80	79.8

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O <sub>2</sub>				
TEMP (F)				
CO				
% EFF				

COMMENTS: ECO:  
REMOVE BOILER #2 & REPLACE WITH SMALL SUMMER BOILER.

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SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY JW DATE 2/11/91

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

**BOILER SURVEY FORM**BOILER #3BOILER MFG.: KEWANEE BOILERLOCATION: 6003 FAR LEFTBOILER TYPE: STEAM ☒ 15 PSIHOT WATER ☐ \_\_\_\_\_ DEG. F SET POINTMODEL NO. L35 350 -KG05BOILER'S CAPACITY: MAX BTUH OUTPUT: 11,716,000

MAX BTUH INPUT: \_\_\_\_\_

BOILER FUEL: OIL ☐ # \_\_\_\_\_GAS ☒ ELECTRIC ☐ OTHER ☐

BURNER MFG.: \_\_\_\_\_

MODEL NO. \_\_\_\_\_

BURNER TYPE FORCE AIR ☒ OPEN FLAME ☐SEASONAL SWITCH OVER: SUMMER \_\_\_\_\_ TO \_\_\_\_\_  
WINTER \_\_\_\_\_ TO \_\_\_\_\_CONTROL MFG.: HONEYWELL R4140G.**STACK TEST:**

TEST 1

	LOW FIRE	50%	75%	HIGH FIRE
%O2	14.2	8.6	10	*
TEMP (F)	240	295	310	
CO	293 PPM	21 PPM	21 PPM	
% EFF	80.4	82.6	81.1	

TEST 2

	LOW FIRE	50%	75%	HIGH FIRE
%O2				
TEMP (F)				
CO				
% EFF				

COMMENTS: \*LINKAGE FELL OFF OF GAS FIRING VL-OPR  
EITHER BOILER NO.1 OR NO.3 SUFFICIENT FOR WINTER.

# BOILER SURVEY FORM.

BLDG. NO 6003

DATE 2-11-91

OPERATOR NAME Dennis Shaw

NUMBER OF BOILER(S) 3

NUMBER OF PUMPS HEATING.                     

	DAILY OPERATION	NIGHT WEEKEND & HOLIDAY OPERATION
NO. OF BOILER ON-LINE <u>2</u>	WINTER <u>2</u> Summer <u>1</u>	SAME SAME
NO. OF PUMP ON-LINE <u>2</u>	WINTER <u>2</u> SUMMER <u>1</u>	SAME SAME

BOILER SHUTDOWN BY OUTSIDE AIR TEMP ☒ NO ☐ YES            TEMP

MONITOR ☒ DAILY ☐ WEEKLY

COMMENTS

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**BOILER COMBUSTION EFFICEINCY TABLE  
FOR NATUARAL GAS**

Table B.1 COMBUSTION EFFICIENCY TABLES FOR NATURAL GAS

## NATURAL GAS

EXCESS AIR	% O <sub>2</sub>	% CO <sub>2</sub>	COMBUSTION EFFICIENCY																
			FLUE GAS TEMPERATURE LESS COMBUSTION AIR TEMPERATURE, DEG F																
			170	180	190	200	210	220	230	240	250	260	270	280	290	300			
0.0	0.0	11.8	86.3	86.1	85.9	85.7	85.5	85.3	85.1	84.9	84.7	84.5	84.2	84.0	83.8	83.6			
2.2	0.5	11.5	86.3	86.1	85.9	85.6	85.4	85.2	85.0	84.8	84.6	84.4	84.1	83.9	83.7	83.5			
4.5	1.0	11.2	86.2	86.0	85.8	85.6	85.3	85.1	84.9	84.7	84.5	84.2	84.0	83.8	83.6	83.4			
6.9	1.5	11.0	86.1	85.9	85.7	85.5	85.2	85.0	84.8	84.6	84.4	84.1	83.9	83.7	83.5	83.2			
9.5	2.0	10.7	86.1	85.8	85.6	85.4	85.2	84.9	84.7	84.5	84.2	84.0	83.8	83.6	83.3	83.1			
12.1	2.5	10.4	86.0	85.7	85.5	85.3	85.1	84.8	84.6	84.4	84.1	83.9	83.7	83.4	83.2	83.0			
15.0	3.0	10.1	85.9	85.7	85.4	85.2	85.0	84.7	84.5	84.2	84.0	83.8	83.5	83.3	83.0	82.8			
18.0	3.5	9.8	85.8	85.6	85.3	85.1	84.8	84.6	84.4	84.1	83.9	83.6	83.4	83.1	82.9	82.6			
21.1	4.0	9.6	85.7	85.5	85.2	85.0	84.7	84.5	84.2	84.0	83.7	83.5	83.2	83.0	82.7	82.5			
24.5	4.5	9.3	85.6	85.4	85.1	84.8	84.6	84.3	84.1	83.8	83.6	83.3	83.1	82.8	82.6	82.3			
28.1	5.0	9.0	85.5	85.2	85.0	84.7	84.5	84.2	83.9	83.7	83.4	83.2	82.9	82.7	82.4	82.1			
31.9	5.5	8.7	85.4	85.1	84.9	84.6	84.3	84.1	83.8	83.5	83.3	83.0	82.7	82.5	82.2	81.9			
35.9	6.0	8.4	85.3	85.0	84.7	84.4	84.2	83.9	83.6	83.3	83.1	82.8	82.5	82.2	82.0	81.7			
40.3	6.5	8.2	85.1	84.9	84.6	84.3	84.0	83.7	83.4	83.2	82.9	82.6	82.3	82.0	81.7	81.5			
44.9	7.0	7.9	85.0	84.7	84.4	84.1	83.8	83.5	83.3	83.0	82.7	82.4	82.1	81.8	81.5	81.2			
49.9	7.5	7.6	84.8	84.5	84.2	84.0	83.7	83.4	83.1	82.8	82.5	82.2	81.9	81.6	81.3	80.9			
55.3	8.0	7.3	84.7	84.4	84.1	83.8	83.5	83.1	82.8	82.5	82.2	81.9	81.6	81.3	81.0	80.7			
61.1	8.5	7.0	84.5	84.2	83.9	83.6	83.2	82.9	82.6	82.3	82.0	81.6	81.3	81.0	80.7	80.4			
67.3	9.0	6.7	84.3	84.0	83.7	83.3	83.0	82.7	82.3	82.0	81.7	81.4	81.0	80.7	80.4	80.0			
74.2	9.5	6.5	84.1	83.8	83.4	83.1	82.8	82.4	82.1	81.7	81.4	81.0	80.7	80.3	80.0	79.7			
81.6	10.0	6.2	83.9	83.5	83.2	82.8	82.5	82.1	81.8	81.4	81.1	80.7	80.3	80.0	79.6	79.3			
89.8	10.5	5.9	83.6	83.3	82.9	82.5	82.2	81.8	81.4	81.1	80.7	80.3	79.9	79.5	79.2	78.8			
98.7	11.0	5.6	83.4	83.0	82.6	82.2	81.8	81.5	81.1	80.7	80.3	79.9	79.4	79.0	78.7	78.3			
108.7	11.5	5.3	83.1	82.7	82.3	81.9	81.5	81.1	80.7	80.3	79.8	79.4	78.9	78.5	78.2	77.8			
119.7	12.0	5.1	82.7	82.3	81.9	81.5	81.1	80.6	80.2	79.7	79.3	78.8	78.4	77.9	77.5	77.2			
132.0	12.5	4.8	82.4	81.9	81.5	81.0	80.6	80.2	79.6	79.1	78.7	78.2	77.7	77.3	76.8	76.6			
145.8	13.0	4.5	82.0	81.5	81.0	80.6	80.1	79.6	79.0	78.5	78.0	77.5	77.0	76.5	76.0	75.8			
161.5	13.5	4.2	81.5	81.0	80.5	80.0	79.5	79.0	78.5	77.8	77.2	76.7	76.2	75.7	75.1	74.6			
179.5	14.0	3.9	81.0	80.4	79.9	79.4	78.8	78.3	77.8	77.1	76.4	75.8	75.2	74.7	74.1	73.5			
200.2	14.5	3.7	80.3	79.8	79.2	78.6	78.1	77.5	76.9	76.4	75.8	75.2	74.7	74.1	73.5	72.9			
224.3	15.0	3.4	79.6	79.0	78.4	77.8	77.2	76.6	76.0	75.3	74.7	74.1	73.5	72.9	72.3	71.7			

Table B.1 COMBUSTION EFFICIENCY TABLES FOR NATURAL GAS

## NATURAL GAS

EXCESS AIR	% O <sub>2</sub>	% CO <sub>2</sub>	COMBUSTION EFFICIENCY															
			FLUE GAS TEMPERATURE LESS COMBUSTION AIR TEMPERATURE, DEG F															
			310	320	330	340	350	360	370	380	390	400	410	420	430	440		
0.0	0.0	11.8	83.4	83.2	83.0	82.8	82.5	82.3	82.1	81.9	81.7	81.5	81.2	81.0	80.8	80.6	80.6	
2.2	0.5	11.5	83.3	83.1	82.8	82.6	82.4	82.2	82.0	81.7	81.5	81.3	81.1	80.9	80.7	80.5	80.4	
4.5	1.0	11.2	83.1	82.9	82.7	82.5	82.3	82.0	81.8	81.6	81.4	81.1	80.9	80.7	80.5	80.3	80.2	
6.9	1.5	11.0	83.0	82.8	82.6	82.3	82.1	81.9	81.6	81.4	81.2	81.0	80.7	80.5	80.3	80.1	79.8	
9.5	2.0	10.7	82.9	82.6	82.4	82.2	81.9	81.7	81.5	81.2	81.0	80.8	80.5	80.3	80.1	79.9	79.6	
12.1	2.5	10.4	82.7	82.5	82.3	82.0	81.8	81.5	81.3	81.1	80.8	80.6	80.3	80.1	79.9	79.7	79.4	
15.0	3.0	10.1	82.6	82.3	82.1	81.8	81.6	81.4	81.1	80.9	80.6	80.4	80.1	79.9	79.7	79.4	79.2	
18.0	3.5	9.8	82.4	82.2	81.9	81.7	81.4	81.2	80.9	80.7	80.4	80.2	79.9	79.7	79.4	79.2	78.9	
21.1	4.0	9.6	82.2	82.0	81.7	81.5	81.2	81.0	80.7	80.5	80.2	79.9	79.7	79.4	79.2	78.9	78.7	
24.5	4.5	9.3	82.0	81.8	81.5	81.3	81.0	80.8	80.5	80.2	80.0	79.7	79.4	79.2	78.9	78.6	78.4	
28.1	5.0	9.0	81.8	81.6	81.3	81.1	80.8	80.5	80.3	80.0	79.7	79.5	79.2	78.9	78.6	78.4	78.1	
31.9	5.5	8.7	81.6	81.4	81.1	80.8	80.6	80.3	80.0	79.7	79.5	79.2	78.9	78.6	78.3	78.0	77.8	
35.9	6.0	8.4	81.4	81.1	80.9	80.6	80.3	80.0	79.7	79.5	79.2	78.9	78.6	78.3	78.0	77.7	77.4	
40.3	6.5	8.2	81.2	80.9	80.6	80.3	80.0	79.7	79.4	79.1	78.8	78.5	78.2	77.9	77.6	77.3	77.0	
44.9	7.0	7.9	80.9	80.6	80.3	80.0	79.7	79.4	79.1	78.8	78.5	78.2	77.9	77.6	77.3	77.0	76.7	
49.9	7.5	7.6	80.6	80.3	80.0	79.7	79.4	79.1	78.8	78.5	78.2	77.9	77.6	77.3	77.0	76.6	76.2	
55.3	8.0	7.3	80.4	80.0	79.7	79.4	79.1	78.8	78.5	78.1	77.8	77.4	77.1	76.8	76.4	76.1	75.8	
61.1	8.5	7.0	80.0	79.7	79.4	79.1	78.7	78.4	78.1	77.8	77.4	77.0	76.6	76.3	76.0	75.6	75.3	
67.3	9.0	6.7	79.7	79.3	79.0	78.7	78.3	78.0	77.7	77.3	76.9	76.5	76.2	75.8	75.5	75.1	74.7	
74.2	9.5	6.5	79.3	79.0	78.6	78.3	77.9	77.6	77.2	76.9	76.5	76.0	75.6	75.3	74.9	74.5	74.2	
81.6	10.0	6.2	78.9	78.5	78.2	77.8	77.5	77.1	76.7	76.4	76.0	75.4	75.0	74.7	74.3	73.9	73.5	
89.8	10.5	5.9	78.4	78.1	77.7	77.3	76.9	76.6	76.2	75.8	75.4	74.8	74.4	74.0	73.6	73.2	72.8	
98.7	11.0	5.6	78.0	77.6	77.2	76.8	76.4	76.0	75.6	75.2	74.8	74.1	73.7	73.3	72.9	72.4	72.0	
108.7	11.5	5.3	77.4	77.0	76.6	76.2	75.8	75.4	74.9	74.5	74.1	73.3	72.9	72.5	72.0	71.6	71.2	
119.7	12.0	5.1	76.8	76.4	75.9	75.5	75.1	74.6	74.2	73.8	73.3	72.5	72.0	71.6	71.1	70.6	70.2	
132.0	12.5	4.8	76.1	75.7	75.2	74.8	74.3	73.9	73.4	72.9	72.5	71.5	71.0	70.6	70.1	69.6	69.1	
145.8	13.0	4.5	75.4	74.9	74.4	73.9	73.4	73.0	72.5	72.0	71.5	70.4	69.9	69.4	68.9	68.4	67.9	
161.5	13.5	4.2	74.5	74.0	73.5	73.0	72.5	72.0	71.5	70.9	70.4	69.2	68.6	68.1	67.5	67.0	66.4	
179.5	14.0	3.9	73.5	73.0	72.4	71.9	71.4	70.8	70.3	69.7	69.2	67.7	67.2	66.6	66.0	65.4	64.8	
200.2	14.5	3.7	72.4	71.8	71.2	70.6	70.1	69.5	68.9	68.3	67.7	66.1	65.4	64.8	64.2	63.5	62.9	
224.3	15.0	3.4	71.0	70.4	69.8	69.2	68.6	67.9	67.3	66.7	66.1	65.4	64.8	64.2	63.5	62.9	62.3	

Table B.1 COMBUSTION EFFICIENCY TABLES FOR NATURAL GAS

## NATURAL GAS

EXCESS AIR	%. O <sub>2</sub>	%. CO <sub>2</sub>	COMBUSTION EFFICIENCY																
			FLUE GAS TEMPERATURE LESS COMBUSTION AIR TEMPERATURE, DEG F																
			450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600	610
0.0	0.0	11.8	80.4	80.1	79.9	79.7	79.5	79.3	79.0	78.8	78.6	78.4	78.1	77.9	77.7	77.5	77.2	77.0	76.8
2.2	0.5	11.5	80.2	80.0	79.7	79.5	79.3	79.1	78.8	78.6	78.4	78.2	77.9	77.7	77.5	77.2	77.0	76.8	76.5
4.5	1.0	11.2	80.0	79.8	79.5	79.3	79.1	78.9	78.6	78.4	78.2	77.9	77.7	77.5	77.2	77.0	76.8	76.5	76.2
6.9	1.5	11.0	79.8	79.6	79.3	79.1	78.9	78.7	78.4	78.2	77.9	77.7	77.5	77.2	77.0	76.7	76.5	76.2	75.9
9.5	2.0	10.7	79.6	79.4	79.1	78.9	78.7	78.4	78.2	77.9	77.7	77.4	77.2	76.9	76.7	76.4	76.2	75.9	75.6
12.1	2.5	10.4	79.4	79.1	78.9	78.7	78.4	78.2	77.9	77.7	77.4	77.2	76.9	76.7	76.4	76.1	75.8	75.5	75.3
15.0	3.0	10.1	79.2	78.9	78.7	78.4	78.2	77.9	77.7	77.4	77.2	76.9	76.7	76.4	76.1	75.8	75.5	75.2	74.9
18.0	3.5	9.8	78.9	78.7	78.4	78.2	77.9	77.6	77.4	77.1	76.8	76.6	76.3	76.0	75.7	75.4	75.1	74.8	74.5
21.1	4.0	9.6	78.7	78.4	78.1	77.9	77.6	77.3	77.0	76.7	76.4	76.1	75.8	75.5	75.2	74.9	74.6	74.3	74.0
24.5	4.5	9.3	78.4	78.1	77.9	77.6	77.3	77.0	76.7	76.4	76.1	75.8	75.5	75.2	74.9	74.6	74.3	74.0	73.7
28.1	5.0	9.0	78.1	77.8	77.6	77.3	77.0	76.7	76.4	76.1	75.8	75.5	75.2	74.9	74.6	74.3	74.0	73.7	73.3
31.9	5.5	8.7	77.8	77.5	77.2	76.9	76.6	76.3	76.0	75.7	75.4	75.1	74.8	74.5	74.2	73.9	73.6	73.3	72.8
35.9	6.0	8.4	77.5	77.2	76.9	76.6	76.3	76.0	75.7	75.4	75.1	74.8	74.5	74.2	73.9	73.6	73.3	72.8	72.2
40.3	6.5	8.2	77.1	76.8	76.5	76.2	75.9	75.6	75.3	75.0	74.7	74.4	74.1	73.8	73.5	73.2	72.9	72.6	72.2
44.9	7.0	7.9	76.7	76.4	76.1	75.8	75.5	75.2	74.9	74.6	74.3	74.0	73.7	73.4	73.1	72.8	72.5	72.2	71.7
49.9	7.5	7.6	76.3	76.0	75.7	75.4	75.1	74.8	74.5	74.2	73.9	73.6	73.3	73.0	72.7	72.4	72.1	71.8	71.4
55.3	8.0	7.3	75.9	75.6	75.3	75.0	74.7	74.4	74.1	73.8	73.5	73.2	72.9	72.6	72.3	72.0	71.7	71.4	71.1
61.1	8.5	7.0	75.4	75.1	74.8	74.5	74.2	73.9	73.6	73.3	73.0	72.7	72.4	72.1	71.8	71.5	71.2	70.9	70.4
67.3	9.0	6.7	74.9	74.6	74.3	74.0	73.7	73.4	73.1	72.8	72.5	72.2	71.9	71.6	71.3	71.0	70.7	70.4	69.7
74.2	9.5	6.5	74.4	74.1	73.8	73.5	73.2	72.9	72.6	72.3	72.0	71.7	71.4	71.1	70.8	70.5	70.2	69.9	68.9
81.6	10.0	6.2	73.8	73.5	73.2	72.9	72.6	72.3	72.0	71.7	71.4	71.1	70.8	70.5	70.2	69.9	69.6	68.9	68.1
89.8	10.5	5.9	73.1	72.8	72.5	72.2	71.9	71.6	71.3	71.0	70.7	70.4	70.1	69.8	69.5	69.2	68.9	68.1	67.1
98.7	11.0	5.6	72.4	72.1	71.8	71.5	71.2	70.9	70.6	70.3	70.0	69.7	69.4	69.1	68.8	68.5	68.2	67.5	66.1
108.7	11.5	5.3	71.6	71.3	71.0	70.7	70.4	70.1	69.8	69.5	69.2	68.9	68.6	68.3	68.0	67.7	67.4	66.5	64.9
119.7	12.0	5.1	70.7	70.4	70.1	69.8	69.5	69.2	68.9	68.6	68.3	68.0	67.7	67.4	67.1	66.8	66.5	65.4	63.6
132.0	12.5	4.8	69.7	69.4	69.1	68.8	68.5	68.2	67.9	67.6	67.3	67.0	66.7	66.4	66.1	65.8	65.5	64.1	62.2
145.8	13.0	4.5	68.6	68.3	68.0	67.7	67.4	67.1	66.8	66.5	66.2	65.9	65.6	65.3	65.0	64.7	64.4	62.7	60.5
161.5	13.5	4.2	67.3	67.0	66.7	66.4	66.1	65.8	65.5	65.2	64.9	64.6	64.3	64.0	63.7	63.4	63.1	61.1	58.7
179.5	14.0	3.9	65.9	65.6	65.3	65.0	64.7	64.4	64.1	63.8	63.5	63.2	62.9	62.6	62.3	62.0	61.7	59.2	56.5
200.2	14.5	3.7	64.2	63.9	63.6	63.3	63.0	62.7	62.4	62.1	61.8	61.5	61.2	60.9	60.6	60.3	60.0	57.1	54.0
224.3	15.0	3.4	62.3	62.0	61.7	61.4	61.1	60.8	60.5	60.2	59.9	59.6	59.3	59.0	58.7	58.4	58.1	54.6	51.0

Table B.1 COMBUSTION EFFICIENCY TABLES FOR NATURAL GAS

## NATURAL GAS

EXCESS AIR	% O <sub>2</sub>	% CO <sub>2</sub>	COMBUSTION EFFICIENCY																
			FLUE GAS TEMPERATURE LESS COMBUSTION AIR TEMPERATURE, DEG F																
			590	600	610	620	630	640	650	660	670	680	690	700	710	720			
0.0	0.0	11.8	77.2	77.0	76.8	76.6	76.3	76.1	75.9	75.7	75.4	75.2	75.0	74.7	74.5	74.3			
2.2	0.5	11.5	77.0	76.8	76.6	76.3	76.1	75.9	75.6	75.4	75.2	74.9	74.7	74.5	74.2	74.0			
4.5	1.0	11.2	76.8	76.5	76.3	76.1	75.8	75.6	75.4	75.1	74.9	74.6	74.4	74.2	73.9	73.7			
6.9	1.5	11.0	76.5	76.3	76.0	75.8	75.6	75.3	75.1	74.8	74.6	74.3	74.1	73.9	73.6	73.4			
9.5	2.0	10.7	76.2	76.0	75.8	75.5	75.3	75.0	74.8	74.5	74.3	74.0	73.8	73.5	73.3	73.0			
12.1	2.5	10.4	76.0	75.7	75.5	75.2	75.0	74.7	74.5	74.2	74.0	73.7	73.4	73.2	72.9	72.7			
15.0	3.0	10.1	75.7	75.4	75.1	74.9	74.6	74.4	74.1	73.9	73.6	73.4	73.1	72.8	72.6	72.3			
18.0	3.5	9.8	75.3	75.1	74.8	74.6	74.3	74.0	73.8	73.5	73.2	73.0	72.7	72.5	72.2	71.9			
21.1	4.0	9.6	75.0	74.7	74.5	74.2	73.9	73.7	73.4	73.1	72.9	72.6	72.3	72.0	71.8	71.5			
24.5	4.5	9.3	74.6	74.4	74.1	73.8	73.5	73.3	73.0	72.7	72.4	72.2	71.9	71.6	71.3	71.1			
28.1	5.0	9.0	74.3	74.0	73.7	73.4	73.1	72.9	72.6	72.3	72.0	71.7	71.4	71.2	70.9	70.6			
31.9	5.5	8.7	73.8	73.6	73.3	73.0	72.7	72.4	72.1	71.8	71.5	71.3	71.0	70.7	70.4	70.1			
35.9	6.0	8.4	73.4	73.1	72.8	72.5	72.2	71.9	71.6	71.4	71.1	70.8	70.5	70.2	69.9	69.6			
40.3	6.5	8.2	73.0	72.7	72.4	72.0	71.7	71.4	71.1	70.8	70.5	70.2	69.9	69.6	69.3	69.0			
44.9	7.0	7.9	72.5	72.1	71.8	71.5	71.2	70.9	70.6	70.3	70.0	69.6	69.3	69.0	68.7	68.4			
49.9	7.5	7.6	71.9	71.6	71.3	71.0	70.6	70.3	70.0	69.7	69.4	69.0	68.7	68.4	68.1	67.7			
55.3	8.0	7.3	71.4	71.0	70.7	70.4	70.0	69.7	69.4	69.0	68.7	68.4	68.0	67.7	67.4	67.0			
61.1	8.5	7.0	70.7	70.4	70.1	69.7	69.4	69.0	68.7	68.3	68.0	67.6	67.3	67.0	66.6	66.3			
67.3	9.0	6.7	70.1	69.7	69.4	69.0	68.6	68.3	67.9	67.6	67.2	66.9	66.5	66.2	65.8	65.4			
74.2	9.5	6.5	69.3	69.0	68.6	68.2	67.9	67.5	67.1	66.8	66.4	66.0	65.7	65.3	64.9	64.5			
81.6	10.0	6.2	68.5	68.2	67.8	67.4	67.0	66.6	66.3	65.9	65.5	65.1	64.7	64.3	63.9	63.6			
89.8	10.5	5.9	67.7	67.3	66.9	66.5	66.1	65.7	65.3	64.9	64.5	64.1	63.7	63.3	62.9	62.5			
98.7	11.0	5.6	66.7	66.3	65.9	65.5	65.1	64.6	64.2	63.8	63.4	63.0	62.6	62.1	61.7	61.3			
108.7	11.5	5.3	65.7	65.2	64.8	64.4	63.9	63.5	63.1	62.6	62.2	61.8	61.3	60.9	60.4	60.0			
119.7	12.0	5.1	64.5	64.0	63.6	63.1	62.7	62.2	61.8	61.3	60.8	60.4	59.9	59.5	59.0	58.6			
132.0	12.5	4.8	63.2	62.7	62.2	61.7	61.3	60.8	60.3	59.8	59.3	58.9	58.4	57.9	57.4	56.9			
145.8	13.0	4.5	61.7	61.2	60.7	60.2	59.7	59.2	58.7	58.2	57.7	57.1	56.6	56.1	55.6	55.1			
161.5	13.5	4.2	60.0	59.5	58.9	58.4	57.9	57.3	56.8	56.3	55.7	55.2	54.7	54.1	53.6	53.0			
179.5	14.0	3.9	58.1	57.5	57.0	56.4	55.8	55.3	54.7	54.1	53.6	53.0	52.4	51.8	51.3	50.7			
200.2	14.5	3.7	55.9	55.3	54.7	54.1	53.5	52.9	52.3	51.6	51.0	50.4	49.8	49.2	48.6	48.0			
224.3	15.0	3.4	53.3	52.7	52.0	51.4	50.7	50.1	49.4	48.7	48.1	47.4	46.8	46.1	45.5	44.8			

**APPENDIX G**

**CENTRAL HEATING PLANT 3442, DD1391**

1. DATE		2. FISCAL YEAR		MILITARY CONSTRUCTION PROJECT DATA				3. DEPARTMENT		4. INSTALLATION	
17 Nov 79		1982						Army		Fort Sill, Oklahoma	
3. PROPOSED AUTHORIZATION		6. PRIOR AUTHORIZATION		7. CATEGORY CODE NUMBER		8. PROGRAM ELEMENT NUMBER		9. STATE/COUNTRY			
\$ 1,941,100.		P.L.		89045				Oklahoma			
10. PROPOSED APPROPRIATION		11. BUDGET ACCOUNT NUMBER		12. PROJECT NUMBER		13. PROJECT TITLE					
\$ 1,941,100.				B408-T497		3442 Central Heating Plant Addition (ECIP)					
SECTION A - DESCRIPTION OF PROJECT											
14. TYPE OF CONSTRUCTION											
15. PHYSICAL CHARACTERISTICS OF PRIMARY FACILITY											
16. PERMANENT											
17. SEMI-PERMANENT											
18. TEMPORARY											
19. TYPE OF WORK											
20. NEW FACILITY											
21. ADDITION											
22. ALTERATION											
23. CONVERSION											
24. OTHER (Specify)											
25. REPLACEMENT											
26. TYPE OF DESIGN											
27. STANDARD DESIGN											
28. SPECIAL DESIGN											
29. DRAWING NO.											
20. PRIMARY FACILITY											
21. SUPPORTING FACILITIES											
22. TOTAL PROJECT COST											
SECTION B - COST ESTIMATES											
23. REQUIREMENT FOR PROJECT											
24. QUANTITATIVE DATA											
25. TOTAL REQUIREMENT											
26. EXISTING SUBSTANDARD											
27. EXISTING ADEQUATE											
28. FUNDED, NOT IN INVENTORY											
29. ADEQUATE ASSETS (C + D)											
30. UNFUNDED PRIOR AUTHORIZATION											
31. INCLUDED IN FY											
32. DEFICIENCY (A - B - C - D)											
33. RELATED PROJECTS											
25. REQUIREMENT FOR PROJECT This Central Heating Plant project is required for more efficient plant operation and will significantly reduce energy consumption in 24 existing & permanent buildings. It will have immediate capability of converting natural gas to oil in accordance with AR420-49 18 Nov '76. (a fuel comparison shows fuel-oil more economically justifiable than coal). A continuous detailed surveillance of this plant will enable DPAE to provide for more effective, timely maintenance of new equipment which will replace several inefficient, oversized boilers and pumps that are nearing the end of their economic life. This project has been reviewed and it has been determined that an "environmental impact statement" pursuant to P.L. 91-190 is not required.											
This project will realize the following annual savings:											
MONETARY: \$306,693.											
AMORTIZATION PERIOD: 6.3 Years											
SAVINGS PER \$1000 (C): 34.6											
BENEFIT/COST RATIO: 2.2											
TOTAL ENERGY: 67,180 MBTU											
ELECTRICITY: (-) 219,047 KWH											
NATURAL GAS: 65,175 KCF											

DD FORM 1391

17 Nov 1979

Fort Sill

3442 Central Heating Plant Addition

Project No. B408-T497

1. GENERAL. This Project is oriented toward curtailing the use of energy by the construction of a Central Heating Plant to replace multiple plants now serving 24 buildings. System to include diversity and provide more efficient operation and maintenance. Natural gas as a fuel is to be supplemented with #2 fuel oil with this project.

2. ACCOMMODATIONS NOW IN USE.

Bldg. No.	Type Const	Use	Gross	
			SF	
2470	P	EM Barracks w/Mess	40,160	
2471	P	EM Barracks w/Mess	40,160	
3411	P	EM Barracks w/Mess	36,569	
3412	P	EM Barracks w/o Mess	36,569	
3413	P	EM Barracks w/Mess	36,569	
3414	P	EM Barracks w/o Mess	36,569	
3415	P	EM Barracks w/Mess	36,569	
3416	P	EM Barracks w/o Mess	36,569	
3417	P	EM Barracks w/Mess	36,569	
3418	P	EM Barracks w/o Mess	36,569	
3419	P	EM Barracks w/Mess	36,569	
3420	P	EM Barracks w/o Mess	36,569	
3421	P	EM Barracks w/Mess	36,569	
3422	P	EM Barracks w/o Mess	36,569	
3423	P	EM Barracks w/Mess	36,569	
3424	P	EM Barracks w/o Mess	36,569	
3425	P	EM Barracks w/Mess	36,569	
3426	P	EM Barracks w/o Mess	36,569	
3427	P	EM Barracks w/Mess	36,569	
3428	P	EM Barracks w/o Mess	36,569	
3429	P	EM Barracks w/Mess	36,569	
3430	P	EM Barracks w/o Mess	36,569	
3440	P	EM Barracks w/Mess	36,569	
3444	P	Gymnasium	20,339	

17 Nov 1979

Fort Sill

3442 Central Heating Plant Addition

Project No. B408-T497

3. ANALYSIS OF DEFICIENCY. The existing 23 barracks and gymnasium were constructed in 1954 with individual heating boilers. The economic life of boilers is approaching the end of the long term investment. Furthermore, the boilers were designed for high pressure steam, but were converted to low pressure shortly after installation resulting in lowered efficiencies. The DFAE personnel are required to make numerous trips to these buildings to repair or replace worn out parts and the expense of boiler repairs is becoming prohibitive. These boilers are not water-treated at the present time. The installation of a new Central Heating Plant will save a considerable amount of energy as well as maintenance dollars. It will provide greater thermal efficiencies by way of new equipment and diversification of loads; and it will centralize operation and maintenance to a more efficient status. The present cost of visiting 24 different plants will be greatly reduced.

#### 4. CONSIDERATION OF ALTERNATE FACILITIES & LOCATIONS.

Not applicable.

5. CRITERIA OF PROPOSED CONSTRUCTION. The proposed Facility will consist of 3 High Temperature Hot Water Boilers and pumps to circulate through a direct-bury piping system essentially paralleling an existing (but recent installation) chilled water circuit. Also to include the removal of 48 existing boilers in 24 buildings. Emissions from new boiler plant will be less than existing due to more efficient firing of boilers. Present boilers are natural gas-fired. The proposed facility will utilize #2 fuel oil as a back-up to new gas-fired boilers.

6. PROGRAMS FOR RELATED FURNISHINGS & EQUIPMENT. Equipment intended for installation is to be procured with a portion of the total funds requested.

7. DISPOSAL OF PRESENT ASSETS. Existing controls, heat-exchangers, pumps, etc. that cannot be adapted to the proposed system will be excessed as defined by the Architect-Engineer who designs the system.

8. SURVIVAL MEASURES.

Not applicable.

9. ENVIRONMENTAL IMPACT. This proposed project has favorable environmental impact as it will conserve natural resources. This project is not deemed a major action significantly affecting the human environment nor is it controversial. Therefore, an environmental impact statement pursuant to Public Law 91-190 is not required.

#### 10. EVALUATION OF FLOOD HAZARDS.

Not applicable.

11. ECONOMIC SAVINGS. An economic analysis is attached herewith. It shows an amortization period of 6.3 years. Savings include fuel reduction and less equipment maintenance cost.

12. UTILITIES SUPPORT. This project is designed to reduce utilities, therefore no additional utilities support will be required for this project.

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Fort Sill

3442 Central Heating Plant Addition

Project No. D408-T497

13. PROTECTION OF CULTURAL ENVIRONMENT. This project has no impact on any designated historical place.
14. PROJECT DEVELOPMENT BROCHURE. The Project Development Brochure Part 1, has been prepared for this project.
15. ENERGY REQUIREMENTS.
- a. Project Description. The proposed Central Heating Plant is an addition to an existing Chilled Water Central Plant & will include new dual fuel boilers & central pumping of high temperature hot water to 24 existing buildings. Existing steam heating boilers will be removed and heat exchangers will be installed to convert HHW to steam. Secondary pumping will not be required; however existing steam condensate pumps to be refurbished and reused. New controls will be required.
- b. Estimated Energy Consumption.
- (1). These are existing facilities with individual heating plants. This proposed project will reduce energy use as follows:
- (2). Energy used for heating will be reduced by use of equipment at maximum efficiencies and through diversification of loads.
- (3). Hot water services will be maintained at minimum temperatures required.
- (4). Electrical power will be increased minimally (219047 kWh/Yr.) in pumping, boiler equipment and lighting to produce fuel savings.
- (5). Sewerage system will be centralized to reduce overall usage of existing facilities.
- c. Energy Sources.
- (1). Heating is presently generated from natural gas in existing 24 plants. These plants are 25 years old and are in fair condition. By installing larger equipment in the new proposed facility, consumption of fossil fuel, in general, would be dramatically reduced.
- (2). Electrical power is provided by contract and is within present system capability.
- (3). Water supply is provided by City of Lawton and will not increase.
- (4). Sewerage system is Government owned and overall requirements will not change.
- d. Energy Use Impacts. This is an energy conservation project, therefore it will have a favorable impact.
- e. Energy Conservation. This project will reduce the annual natural gas consumption approximately 65 MCF/Year.
- f. Energy Alternatives. This is a modification project to existing systems to conserve energy sources. Although and alternate fuel back-up could be coal in lieu of fuel-oil an economic comparison has been made and found to be not advantageous. Also the present site does not lend itself readily to coal storage.
- g. Energy Effects-Environmental Effects. This project has no environmental effects from energy systems intended.

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3442 Central Heating Plant Addition

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16. PROVISIONS FOR HANDICAPPED. In accordance with PL90-480, no provision for the handicapped will be made in the project since, in the foreseeable future, the facility will be used and operated solely by able-bodied personnel.

*Jack L. Van Pool*  
JACK L. VAN POOL  
Colonel, FA

Deputy Installation Commander

# BUDGETARY ESTIMATE DATA

Anticipated Construction Start Date: Apr 1982  
 Anticipated Construction Completion Date: Apr 1983  
 Anticipated Midpoint of Construction Date: Oct 1982  
 Construction Cost Index for Anticipated Midpoint of Construction Date: 2158

Fort Sill, Oklahoma FY 1982 17 Nov 1979  
 Project No. B408-T497  
 Description: 3442 Central Heating Plant Addition (ECIP)

	<u>Quantity</u>	<u>Unit</u>	<u>Unit Cost</u>	<u>Total</u> <u>(\$000)</u>
1. <u>Primary Facility</u>				
a. Central Plant Bldg. Addition (\$41. x 2158 + 1719 = \$51.47)	4,600	SF	51.47	237.
b. Boilers & Associated Equipment	3	Ea.	LS	1,183.
c. HTHW Pumps	3	Ea.	LS	8.
2. <u>Supporting Facility</u>				
a. Heating Water Piping Distribution	12,140	LF	23.55	286.
b. Retrofit Existing Bldgs.	24	Ea.	LS	79.
c. Electrical Work			LS	20.
d. Site Work			LS	30.
e. Fuel Storage Tanks	2	Ea.	15,000	30.
f. Recording Instruments, Meters, Controls			LS	62.
g. Gas Service To New C. H. P.			LS	6.
TOTAL ESTIMATED COST				1,941.

## ECONOMIC ANALYSIS (ECIP)

Location: Fort Sill, Oklahoma FY 1982  
 Project: 3442 Central Heating Plant Addition  
Project No. B408-T497  
 Economic Life 25 Yrs. Date Prepared 17 Nov 1979 Prepared By C. Robert Scruggs

COSTS

## 1. Non-recurring Initial Capital Costs.

a. CWE	\$ 1,941,100.
b. Design	\$ 104,641.
c. Salvage	\$ 1,512. (-)
d. Total	\$ 2,044,229.

BENEFITS

## 2. Recurring Benefit/Cost Differential Other Than Energy

a. Annual Labor Decrease (+)/ Increase (-)	\$ 136,390. /Yr. (+)
b. Annual Material Decrease (+)/ Increase (-)	\$ 27,786. /Yr. (+)
c. Other Annual Decrease (+) /Increase (-)	\$ - /Yr.
d. Total Costs	\$ 164,176. /Yr. (+)
e. 10% Discount Factor	9.524
f. Discounted Recurring Cost (d x e)	\$ 1,563,612. (+)

## 3. Recurring Energy Benefit/Costs

a. Type of Fuel Electricity

(1) Annual Energy Decrease (+)/ Increase (-)	1,906. MBTU (-)
(2) Cost per MBTU	\$ 2.07 /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	\$ 3,945. /Yr. (-)
(4) Differential Escalation Rate ( 7 % ) Factor	18.049
(5) Discounted Dollar Decrease/Increase ((3)x(4))	\$ 71,203. (-)

b. Type of Fuel Electric Demand

(1) Annual Energy Decrease (+)/ Increase (-)	N/A MBTU
(2) Cost per MBTU	\$ - /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	\$ - /Yr.
(4) Differential Escalation Rate ( 7 % ) Factor	-
(5) Discounted Dollar Decrease/Increase ((3)x(4))	\$ -

c. Type of Fuel Natural Gas

(1) Annual Energy Decrease (+)/ Increase (-)	69,086. MBTU (+)
(2) Cost per MBTU	\$ 2.12 MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	\$ 146,462. /Yr. (+)
(4) Differential Escalation Rate ( 8 % ) Factor	20.050
(5) Discounted Dollar Decrease/Increase ((3)x(4))	\$ 2,976,563. (+)

d. Type of Fuel -

(1) Annual Energy Decrease (+)/ Increase (-)	- MBTU
(2) Cost per MBTU	\$ - MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	\$ - /Yr.
(4) Differential Escalation Rate ( % ) Factor	-
(5) Discounted Dollar Decrease/Increase ((3)x(4))	\$ -

e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	\$ 2,865,360.
---	---------------

4. Total Benefits (Sum 2.f + 3e)	\$ 4,428,972.
----------------------------------	---------------

5. Discounted Benefit/Cost Ratio (Line 4 ÷ Line 1d)	2.2
---	-----

6. Total Annual Energy Savings 3a(1)+3b(1)+3c(1)+3d(1)	67,180. MBTU
--	--------------

7. E/C Ratio (Line 6 ÷ (Line 1a/1,000))	34.6
---	------

8. Annual \$ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3))	\$ 306,693.
---	-------------

9. Payback Period ((Line 1a - Salvage) ÷ Line 8)	6.3 YEAR
--	----------

ECONOMIC ANALYSIS (CONT.)

1. Non-recurring Initial Capital Costs:

Construction		\$ 1,443,822.
SIOM @ 5 %		\$ 72,191.
Unescalated CWE		\$ 1,516,013.
CWE (Escalated to End FY 82 ):		
$\$1516013 \times 1.07 \times 1.065 \times 1.06 \times 1.06$	=	\$ 1,941,100.
(Entered on Line 1.a.)		
Unescalated Design @ 6 % of Construction:		
$.06 \times \$ 1,443,822.$	=	\$ 86,629.
Design (Escalated to End FY 81 ):		
$\$86,629. \times 1.07 \times 1.065 \times 1.06 \times -$	=	\$ 104,641.
(Entered on Line 1.b.)		
Salvaged value of removed equipment:	=	\$ 1,200.
Salvage value (Escalated to End FY 82 ):		
$\$1,200. \times 1.064 \times 1.062 \times 1.056 \times 1.056$	=	\$ 1,512.
(Entered on Line 1.c.)		

2. Recurring Benefit (+)/Cost (-) Differential Other Than Energy:

Labor (Unescalated)		\$ 108,240. ( )
Labor (Escalated to End FY 82 )	=	
$\$108,240. \times 1.064 \times 1.062 \times 1.056 \times 1.056$	=	\$ 136,390. (+)
(Entered on Line 2.a.)		
Materials (Unescalated)		\$ 22,051. ( )
Materials (Escalated to End FY 82 ):	=	
$\$22,051. \times 1.064 \times 1.062 \times 1.056 \times 1.056$	=	\$ 27,786. (+)
(Entered on Line 2.b.)		

3. Recurring Energy Benefits (+)/Costs (-):

a. Electric Energy: ((-)219,047.KWH x 8700 BTU/KWH)

MBTU Saved	=	1,906. (-) MBTU
(Entered on Line 3.a.(1).)		
\$ Cost/MBTU	=	\$ 1.207 /MBTU
\$ Cost/MBTU (Escalated to End FY 82 ):		
$\$ 1.207 \times 1.16 \times 1.16 \times 1.13 \times 1.13$	=	\$ 2.07 /MBTU
(Entered on Line 3.2.(2).)		

b. Demand Charge Reduction:

MBTU Saved:		Negligible
Annual Dollar Saving	=	\$ - /Yr.
Annual Dollar Saving (Escalated to End FY 82 ):		
$\$ - \times 1.16 \times 1.16 \times 1.13 \times 1.13$	=	\$ -
(Entered on Line 3.b.(3).)		

c. Natural Gas: (65.175 MCF x 1060 BTU/CF)

MBTU Saved	=	69,086. MBTU
(Entered on Line 3.c.(1).)		
\$ Cost/MBTU	=	\$ 1.231 /MBTU
\$ Cost/MBTU (Escalated to End FY 82 ):		
$\$ 1.231 \times 1.15 \times 1.15 \times 1.14 \times 1.14$	=	\$ 2.12 /MBTU
(Entered on Line 3.c.(2).)		

ABBREVIATIONS

K  
M  
KBH  
MBH  
MBTU/YR. (or MBU/YR)  
CF  
GAL  
KWH

DENOTATION

KILO ( $10^3$ )  
MEGA ( $10^6$ )  
1000 BTU/HR.  
MEGA BTU/HR.  
MEGA BTU/YEAR  
CUBIC FEET  
GALLON  
KILO WATT HOURS

FUEL	COST OF FUEL		REMARKS
	@ FT.SILL	@ SOURCE	
NATURAL GAS (JAN '78)	\$1.305/KCF	\$1.231/MBU	RE: ARKLA GAS COMPANY @ 1060 BTU/CF.
FUEL OIL #2 (JUL '78)	\$0.3789/GAL	\$2.732/MBU	RE: KERR-McGEE COMPANY *1 DISTIL. F.O. @ 138,700 BTU/GAL.
COAL (APR '78)	\$40.75/TON	\$1.658/MBU	RE: ASSOCIATED PRODUCERS COMPANY @ 13,478 BTU/LB OR 26.956 MBU/TON *1 USE: 24.58 MBU/TON
ELECTRICITY (SEPT '78)			RE: PUBLIC SERVICE CO. OF OKLA. & SWPA 25% HYDRO-ELEC. @ \$0.002/KWH TO 4.877 MKWH + \$0.003/KWH ALL OVER 4.877 MKWH
ENERGY CHARGES			75% FOSSIL FUEL @ \$0.01338/KWH: 25% @ \$0.002 = \$0.0005 75% @ \$0.01338 = \$0.0100 \$0.0105/KWH
	\$0.0105/KWH		\$0.0105/KWH (75% x 11,600 BTU/KWH *2) + (25% x 0 BTU/KWH (HYDRO-ELEC.) = \$0.0105 x 8700 = \$1.207/MBU (@ SOURCE)
		\$1.207/MBU	FROM 8700 BTU/KWH TO 3414 BTU/KWH (@ FT.SILL): 2.548 x \$1.207 = \$3.076/MBU (@ FT. SILL)
DEMAND CHARGES			RE: PUBLIC SERVICE CO. OF OKLA. MINIMUM MONTHLY CHARGE BASED ON 32,500 KW x \$1.60 = \$52,000
	\$1.60/KW		

\*1 RE: ECIP

\*2 For this report, we have taken the recommended 11,600 BTU/KWH as given by the ECIP Guidance (DAEN-FEU, 7 Nov. 1977) for Source Energy and derated it 25% or 8700 BTU/KWH because of the advantages Ft. Sill is receiving from hydroelectric generation.

<b>carnahan-thompson-delano. inc.</b> professional consulting engineers PROJECT NO 1367 3442 C.H.P. FEDERAL CONTRACT NO DACA63-77-C-0195	SUBJECT <b>FUEL CHARGES-ENERGY COST-LEGEND</b>	1 OF 13
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK	
	BY <b>CRS-JHG-PRMc</b> DATE <b>23 Feb '79</b>	
	CHK <b>RLS</b> DATE <b>29 June 79</b> REV	

ECONOMIC ANALYSIS BACK-UP

"A"

SCHEDULE OF BLDGS & LOADS

1.	Q	BUILDING	GLASS AREA		TOT. HTG MBH (ea)		LOADS HTG MBH	
			S.F.(ea)	S.F.(Tot)	INSTALLED	DESIGN	INSTALLED	DESIGN
	21	3400 Bks	2627	55167.	2.879	1.256	60.459	26.376
	2	2470-71 Bks	2902	5804.	4.800	1.610	9.600	3.220
	1	3444 Gym	-	-	1.200	2.045	1.200	2.045
		TOTALS		<u>60971. *1</u>			<u>71.259</u>	<u>31.641</u>

2. Reduction in Load due to storm windows added:

$$60971 \text{ SF Glass} \times 40 \text{ BTU/(H)(SF)} \times 2 = 2.439$$

$$\text{New Total Estimated Load} = 29.202 \text{ MBH}$$

3. Higher efficiencies can be maintained with new boilers in a C.E.P. than presently exists with 24 individual, older, gas-fired boilers serving 24 bldgs.

Efficiencies of boilers are taken from an average of those listed herein; reference being made to "Tuning for Maximum Efficiency" (by Elzy Nichols Industrial Gas Publication; dated April 1978). The author states: "Older boilers often have an efficiency of 70%, but for most of them 55% is tops---. Five to ten percent increase can be effected on older units by repairing, cleaning & closing up cracks and holes, but they cannot be brought to the level of a new boiler."

In our judgement from field survey of these facilities, most boilers are of the older type. There are some that have been renovated w/controls, refractories, linkages, etc., which would increase these efficiencies to that referred above if they were maintained properly.

For this study the average, maintained, peak efficiency is conservatively estimated at 60% for existing boilers.

4.  $71.259 \text{ MBH} \times 0.60 = 42.755 \text{ MBH (Exist.)}$

5. Boiler Oversizing to Loads:

$$\frac{42.755 \text{ MBH} - 29.202 \text{ MBH}}{29.202 \text{ MBH}} = 46.4\% \text{ Oversized}$$

6.  $E = \left[ \frac{29.202 \text{ MBH} \times 2899 \text{ DD} \times 24 \text{ Hrs}}{52^{\circ}\text{F} \times 0.60} \right] (.85) (1.89) *3 = 104,620. \text{ MBTU/Yr.}$

With higher efficiencies from new boilers & matching boilers to Load:

$$E = \left[ \frac{29.202 \text{ MBH} \times 2899 \times 24}{52^{\circ}\text{F} \times .70 *4} \right] (.85) (1.36) = 56,459. \text{ MBTU/Yr.}$$

TOTAL E Htg Saved = 48,161. MBTU/Yr.

- \*4 Re: International Boiler Co. Efficiencies  
 \*3 Re: ASHRAE '76, S-43.8 TAB 3 (By Interpolation)  
 \*2 Re: Calculations, (page 10 & 11)  
 \*1 Glass Area for Bldgs w/Storm Windows added in FY '79.

<b>Carnahan-thompson-delano, inc.</b> PROFESSIONAL CONSULTING ENGINEERS PROJECT NO 1367 3442 C.H.P. FEDERAL CONTRACT NO DACA63-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u>		-2- OF 13!
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK		
	BY <u>CRS</u>	DATE <u>17 Nov 79</u>	
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"B" Higher efficiencies for domestic hot water can be maintained with new boilers in a C.E.P. than presently exists. (Ref. to comments in "A" above).

### Consumption Estimate

#### Domestic HW (140°F):

21 Bks @ 190 peop/Bldg + (2 Bks @ 210)	= 4,410 people
4,410 peop x 3.8 GPH/person (Max) *1	= 16,758 GPH
16,758 GPH x 8.33 x 80° Rise	= 11.168 MBH Demand
4,410 x 13.1 GPD/person *1 x 365 day/yr	= 21.086 M Gal/ Yr
21.086 M x 8.33 x (140° - 60°)	= <u>14,052. MBTU/Yr</u>

#### Kitchen HW (140°F):

4,410 peop x 2.5 meals/day (Av'g) x 75% Div.	= 8,269. meals/day Av'g.
8,269 x 1.5 GPH/meal (Max) *1	= 12,404. GPH (Max)
12,404. GPH x 8.33 x 80° Rise	= 8.266 MBH Demand
8,269 meals/day x 2.4 GPD/Av'g meal *1	= 19,846. GPD (140°F)
19,846 x 300 Days/Yr	= 5.953 M Gal/Yr
5.953 M x 8.33 x 80°	= <u>3,968. MBTU/Yr</u>

#### Kitchen HW (180°F) (140°F HW Boosted 40°F)

1.31 *2 x 12,404. GPH Max.	= 16,249. GPH (180°HW)
16,249 x 8.33 x 40° Rise	= 5.414 MBH (Demand 180°)
1.31 x 5.953 M Gal/Yr (140°)	= 7.798 M Gal/Yr (180°)
7.798 M x 8.33 x 40°	= <u>2,598. MBTU/Yr</u>

Total Estimated Dom. & Kitchen Consumption	= <u>20,618. MBTU/Yr</u>
--	--------------------------

E Dom. & Kit. = $\frac{20,618. \text{ MBTU/Yr}}{.60}$	= 34,363. MBTU/Yr
---	-------------------

w/C.E.P. Boiler Efficiency @ 80%	= <u>25,773. MBTU/Yr</u>
----------------------------------	--------------------------

Total Dom. & Kit. HW Saved	= <u>8,590. MBTU/Yr</u>
----------------------------	-------------------------

\*2 Re: ASHRAE '76 S-37.18 - Example Problem #6.

\*1 Re: ASHRAE '76 S-37.11 (TAB 6)

<b>carnahan-thompson-delano, inc.</b> professional consulting engineers PROJECT NO. 1367 3442 C.H.P. FEDERAL CONTRACT NO. DACA63-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u> PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK BY <u>CRS</u> DATE <u>17 Nov 79</u> CHK. <u>CRS</u> DATE _____ REV _____
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3  
OF  
13

"C" Diversity of Loads & Boiler Operation From C.E.P:

Boiler Selection:

From "A" : Heating Connected Load	=	29.202 MBH
From "B" : Domestic Brks (140°F)	=	11.168 MBH
Kitchen (140°F)	=	8.266 MBH
Kitchen (180°F)	=	5.414 MBH
Total Existing Estimated Connected Load	=	<u>54.050 MBH</u>
@ 85% Diversity	=	45.943 MBH
@ 10% Pipe Loss	=	4.594 MBH
New C.E.P. Loss	=	.400 MBH
New Total Estimated Demand	=	50.937 MBH (Max. Winter Design Load)
Winter Max. @ 75% Load for all but one Boiler #1	=	<u>38.202 MBH</u>
Winter Min. @ 65% Load for all but one Boiler	=	<u>33.109 MBH</u>
Summer Min.	=	<u>24.848 MBH</u>
Try: 3 Ea. Gas/oil-fired HTW Boilers @ 20 MBH		

Diversity of Loads:

E (New Htg. Consumption from "A")	=	56,459. MBTU/Yr.
E (New Dom. Consumption from "B")	=	25,773. MBTU/Yr.
E TOTAL	=	82,232. MBTU/Yr.
@ 85% Diversity	=	69,897. MBTU/Yr.
E TOTAL SAVED	=	<u>12,335. MBTU/Yr.</u>

\*1 Re: ETL 1110-3-256, 28 Sep '76

<b>carnahan-thompson-delano, inc.</b> <small>professional consulting engineers</small> PROJECT NO 1367 3442 C.H.P. FEDERAL CONTRACT NO DACA63-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u>	4 OF 13
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK	
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"D" Labor and Material Recurring Costs/Yr.

		\$ / YEAR	
		SAVED (+)	COSTS (-)
1. Maintaining 24 Existing Boiler Plants:			
4 MD/Boiler/Yr. x 48	= 192 MD		
1/2 MD/pump x 48 x 12 Mos/Yr.	= 288 MD		
Operating 48 Boilers:			
1/2 MD/Boiler/Wk. *1 x 48 x 52 Wks.	= 1248 MD		
TOTAL:	@ \$80/Day x 1728 MD	= \$138,240. (L)	
2. Equipment and Materials:			
Replacement of Exist. Boilers for Equiv. Life:			
\$10,000/Boiler x 48	= 480,000/25 Yr.	= 19,200. (H)	
\$ 350/pump x 48	= 16,800/25 Yr.	= 672. (H)	
3. Truck Expense: @ \$10,000/7 Yrs.		= 1,429. (H)	
@ 10¢/Mi. x 7500 Mi/Yr.		= 750. (H)	
4. Operation and Maintenance of New C.E.P.			
1 man x 24 Hrs./Day x 365 Days/Yr. x \$10/Hr.	=		(-) 87,600. (L)
5. Tuning Boilers: 48 Boilers in 24 Plants to be tuned and tested periodically to maintain high effic's. as compared to 3 new boilers:			
Repair and Adjust controls Ea. Boiler - 2 MD			
Test Firing and Cleaning Burners	2 MD		
Clean & Adj. Dampers/Motors/Linkage	2 MD		
CO <sub>2</sub> Testing	2 MD		
Twice Ea. Year: 2 x (48-3) ea. x \$80/Day x 8 MD	=	57,600. (L)	
TOTAL LABOR:		\$195,840.	(-) 87,600.
TOTAL MATERIAL:		\$ 22,051.	
NET LABOR SAVED:		\$108,240.	
NET MATERIAL SAVED:		\$ 22,051.	

\*1 AR420-49 18 Nov 76, Tab 2-1: Operational Visits.

<b>carnahan-thompson-delano, inc.</b> professional consulting engineers PROJECT NO 1367 3442 C.H.P. FEDERAL CONTRACT NO DACA63-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u>	5 OF 13
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK	
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# 1. Retrofit:

Remove 48 exist. Boilers and Water Heaters	LS	=	24,000.
3 HTHW Heat - X's x 24 Bldgs. x \$350/Ea.		=	\$25,200.
Piping @ 24 x \$250/Ea.		=	6,000.
Insulation @ 24 x \$200/Ea.		=	4,800.
Controls @ 24 x \$350/Ea.		=	8,400.
Electrical @ 24 x \$150/Ea.		=	3,600.
Misc.		=	7,200.
TOTAL:			\$79,200.

# 2. Salvage:

Controls in 24 Bldgs. @ \$50/Ea.	=	\$ 1,200.
Boilers	=	-0-
TOTAL:	=	\$ 1,200.

"F" Energy expended in new (proposed) C.E.P. by new gas/oil-fired boiler motor accessories as compared to 24 individual plants presently operating.

ENERGY EXPENDED  
(KWH/Yr.)

# 1. Proposed boiler (3 ea. @ 20 MBH ea):

Forced draft blower motor @ 7.5 Hp ea:

7.5 Hp/boiler x 0.746 KW/Hp = 5.60 KW/20MBH. Boiler  
or 3.58 MBTU/ KWH

E (Add'l) =  $\frac{69,897 \text{ MBTU/Yr.}}{3.58 \text{ MBTU/ KWH}}$  = 19,524.

# 2. Proposed pumping vs. Existing:

Distribution pumping (from FY '82 C.E.P.):

GPM =  $\frac{54.050 \text{ MBH}}{500 \times (380^\circ - 280^\circ)}$  = 1081 GPM

HP =  $\frac{1081 \text{ GPM} \times 100' \text{ HD}}{3960 \times 0.60 \text{ (eff.)}}$  = 46 bHp x 0.746 KW/Hp = 34 KW

E (Add'l) = 34 KW x 8760 Hrs./Yr. x 0.67 (Divers.) = 199,523.

ADDITIONAL ESTIMATED ELECTRICAL CONSUMPTION

219,047.

<b>carnahan-thompson-delano, inc.</b> professional consulting engineers PROJECT NO. 1367 3442 C.H.P. FEDERAL CONTRACT NO DACA63-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u>		6 OF 13
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Σ ENERGY SAVINGS/YEAR (RE: ECIP ECONOMIC ANALYSIS)

METHOD	TOTAL SOURCE ENERGY SAVED MBTU	TOTAL FUEL SAVED ELECTRIC KWH	NAT. GAS MBTU	RECURRING COSTS SAVED *1	OTHER COSTS (INITIAL)	DESCRIPTION OF COST SAVINGS METHOD
"A"	48,161.	-	48,161.	-	-	Higher Efficiencies (HTG)
"B"	8,590.	-	8,590.	-	-	Higher Efficiencies (DOM.)
"C"	12,335.	-	12,335.	-	-	C.E.P. HTG. Water Diversity
"D"	-	-	-	\$108,240.	-	Labor Saved
	-	-	-	22,051.	-	Material Saved
"E"	-	-	-	-	(-) \$79,200.	Retrofit Costs
					(+) 1,200.	Salvage Costs
"F"	(-) 1,906.	(-) 219,047.	-	-	-	Energy Expended W/New C.E.P. Facility
TOTALS:	67,180.	(-)219,047.	69,086.	\$130,291.	(-) \$78,000.	
		((-) 1,906. MBTU/Yr.)	(65,175. MCF/Yr)			

\*1 Other Than Energy

<b>carnahan-thompson-delano. inc.</b> professional consulting engineers PROJECT NO. 1367 3442 C.H.P. FEDERAL CONTRACT NO. DACA83-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u>	7
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK	OF
	BY <u>CRS</u> DATE <u>17 Nov 79</u>	13
	CHK <u>OK</u> DATE _____ REV _____	

	<u>GAS</u>	<u>OIL</u>	<u>COAL</u> *1
C.W.E. (UNESCALATED)	1,443,822.	1,443,822.	2,240,822.
<u>SAVINGS OVER EXISTING:</u>			
E (MBTU/YR)	69,086.	59,101.	64,427.
GAS @ \$1.231/MBTU *2	\$85,045.	\$75,753.	\$79,310.
<u>RECURRING COSTS/YR SAVED OVER EXIST:</u>			
LABOR	\$108,240.	\$108,240.	\$20,640.
MATERIAL	\$22,051.	\$22,051.	\$19,872.
<u>INCREASED ELECTRICAL OVER EXISTING:</u>			
E (KWH/YR)	219,047.	219,047.	246,651.
E (MBTU/YR)	(-)1,906.	(-)1,906.	(-)2,146.
ELECTRICAL COST/YEAR	(-) \$2,300.	(-) \$2,300.	(-) \$2,590.
TOTAL E CONSUMPTION WITH C.H.P. (MBTU/YR)	69,897. @ \$1.231/MBTU	79,882. @ \$2.732/MBTU	74,556. @ \$1.658/MBTU
COSTS/YEAR (ABOVE LEAST EXPENSIVE FUEL AS A BASE)	(86,043.) -0-	(218,238.) (-)132,194.	(123,614.) (-)37,571.
NET COMPARATIVE COST SAVINGS/YR.	\$213,036.	\$71,550.	\$79,661.
NET E SAVED (MBTU/YEAR)	67,180.	57,195.	62,281.
SIMPLE PAY-BACK	6.7	20.2	28.1

\*2 RE: Rate Schedule, Page 1 of 13

\*1 RE: Page 9 of 13

<b>carnahan-thompson-delano, inc.</b> PROFESSIONAL CONSULTING ENGINEERS PROJECT NO. 1367 3442 C.H.P. FEDERAL CONTRACT NO DACA63-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u>		8 OF 13
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK		
	BY <u>CRS</u>	DATE <u>17 Nov 79</u>	
	CHK <u>DRB</u>	DATE _____ REV _____	

1. Total cost (Unescalated from ECIP, Economic Analysis) = \$1,443,822.

Coal Fired Boilers, Additional Cost

a. Central Plant Addition	4600 SF	10.	46,000.
b. Coal & Ash Handling Equipment		LS	300,000.
c. Deduct Fuel-Oil Storage Tanks		LS (-)	30,000.
d. Rail Spur		LS	300,000.
e. Site Preparation		LS	50,000.
f. Scrubbers & Filters		LS	41,000.
g. Boilers		LS	<u>90,000.</u>
TOTAL ADDITIONAL COST	=		\$ 797,000.
TOTAL COST	=		<u>\$2,240,822.</u>

2. REF. TO "A" HEREIN :

E with Oil Fired Boilers @ 70% = 64,525. MBTU/YR, savings = 40,095. MBTU/YR.

E with Coal Fired Boilers @ 75% = 60,223. MBTU/YR, savings = 44,397. MBTU/YR.

3. REF. TO "B" HEREIN :

( with Oil Fired Boilers Eff. @ 70% = 29,454. MBTU/YR, savings = 4,909. MBTU/YR)

( with Coal Fired Boilers Eff. @ 75% = 27,490. MBTU/YR, savings = 6,873. MBTU/YR)

4. REF. TO "C" HEREIN :

		<u>OIL</u>	<u>COAL</u>
E (Heating from "A" )	=	64,525.	60,223.
E (Domestic from "B" )	=	<u>29,454.</u>	<u>27,490.</u>
E Totals MBTU/YR.	=	93,979.	87,713.
@ 85% Diversity	=	<u>79,882.</u>	<u>74,556.</u>
E Saved, Total MBTU/YEAR	=	14,097.	13,157.

5. REF. TO "D" HEREIN :

For Coal Fired Boilers - (Supplement above "D" with the following:

1. Assume Coal & ash handling vehicle expense to balance out with truck expense.		(-) 1,429.(M)
		(-) 750.(M)
2. Additional Labor (Coal & Ash Handling) 3 men @ 8 Hrs/Day x 365 days/Yr x \$10/Hr.		(-) 87,600.(L)
TOTAL LABOR:	\$195,840.	(-) \$175,200.
TOTAL MATERIAL:	\$ 22,051.	(-) \$ 2,179.
NET LABOR SAVED:	\$ 20,640.	
NET MATERIAL SAVED:	\$ 19,872.	

6. REF. TO "F" HEREIN :

For Coal Fired Boilers - (Supplement above "F" with the following:

Coal Stoker forced draft blower	10 Hp
Coal Stoker overfire air blower	7.5 Hp
Coal Stoker hydraulic drive	5 Hp

@ 0.746 KW / Hp X 22½ Hp = 16.8 KW/20 MBH Boiler or 1.19 MBTU/KWH

$$E = \frac{74,556 \text{ MBTU/YR}}{1.19 \text{ MBTU/KWH}} = 62,652. \text{ KWH/YR} = (19,524. \text{ MBTU/YR}) = 43,128 \text{ (Additional)}$$

$$\frac{199,523 \text{ (Pumping)}}{242,651}$$

<b>carnahan-thompson-deland, inc.</b> professional consulting engineers PROJECT NO. 1387 3442 C.H.P. FEDERAL CONTRACT NO DACA63-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u>	9 OF 13
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK	
	BY <u>GRS</u> DATE <u>17 Nov 79</u>	
	CHK <u>GRS</u> DATE <u>17 Nov 79</u> REV <u>1</u>	

# Infiltration Calculations for Storm Windows Added:

Select existing Prime & New Storm Windows for the Basis of this study as follows:

<u>WINDOW</u>	<u>PRIME</u>	<u>STORM</u>
Material	Wood	Alum.
Type	Double Hung	Single Hung
Weatherstripped	Loose Fit	Regular Fit
Size	3'x4' = 12 SF	3'x4' = 12 SF
Crack	17 L.F.	17 L.F.

Winter Infiltration @ 15 mph wind velocity or .1" H<sub>2</sub>O DP

Summer Infiltration @ 7½ mph wind velocity or .025" H<sub>2</sub>O DP

$$*1 \text{ Winter: } 0.5 \text{ CFM/LF} \times 17 \text{ LF} = 8.5 \text{ CFM/Window} \times .6 = \underline{\underline{5.1 \text{ CFM/Window}}}$$

$$*2 \text{ Summer: } 0.25 \text{ CFM/LF} \times 17 \text{ LF} = 4.3 \text{ CFM/Window} \times .6 = \underline{\underline{2.6 \text{ CFM/Window}}}$$

@ ½ Glass Area for Infiltration:

Factors for Infiltration Reduction:

$$\text{Winter: } \frac{(8.5 - 5.1) \text{ CFM/Window}}{12 \text{ SF}} \times \frac{1}{2} = \underline{\underline{.14 \text{ CFM/SF glass}}}$$

$$\text{Summer: } \frac{4.3 - 2.6}{12} \times \frac{1}{2} = \underline{\underline{.07 \text{ CFM/SF}}}$$

Load Reduction by Infiltration:

$$\text{HTG: } .14 \text{ CFM/SF} \times 1.08 \times 52^{\circ}\text{F} = \underline{\underline{7.9 \text{ BTU/(H)(SF)}}}$$

$$\text{CLG: } \left[ (.07 \times 1.08 \times 22^{\circ}\text{F}) + (.07 \times 4840 \times .0036 \text{ \#/\#Dry Air}) \right] = \underline{\underline{2.9 \text{ BTU/(H)(SF)}}}$$

Load Reduction by Adding Storm Glass

Transmission & Solar:\*1

Summer:

Single Flat Glass:

$$U = 1. \text{ w/o Shade}$$

$$U = \underline{\underline{0.81}} \text{ w/Indoor Shade} \leftarrow$$

Glass Shading Coef

$$= 1.0$$

Indoor Shade (Blinds)\*2 Coef

$$= \underline{\underline{0.55}}$$

Transmission:

$$H = UA \text{ (CLTD)}$$

\*3 Clear Glass w/Light colored venetian blinds

\*2 ASHRAE '77 F 25.14

\*1 For both Prime & Storm:

ASHRAE Heating/Cooling Load Calculation Manual, Grp 158, Figs 5.11 & 5.12

<b>carnahan-thompson-delano, inc.</b> PROFESSIONAL CONSULTING ENGINEERS PROJECT NO. 1367 3442 C.H.P. FEDERAL CONTRACT NO DACA63-77-C-0195	SUBJECT <u>Economic Analysis Back-Up</u>	10 OF 13
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT SILL. OK	
	BY <u>CRS</u> DATE <u>17 Nov 79</u>	
	CHK <u>CRS</u> DATE _____ REV _____	

SOLAR: H = A (SC) (SHG) (CLF)  
 MAX, SHG for August, 32° LAT.

TRANSMISSION

TIME	CLTD	U	SOLAR				NORTH		AVERAGE		TRANS. PLUS SOLAR BTU (H) (SF)
			(SHG)	(CLF) = F	(SHG)	(CLF) = F	(SHG)	(CLF) = F	F	(SC)	
SINGLE 1400	13	.81	111.	.71	79.	.53	219.	.88	33.	76	.55
GLASS 1600	14	.81	111.	.37	41.	.83	219.	.77	28.	84	.55
1800	12	.81	111.	.20	22.	.63	219.	.92	34.	65	.55
DOUBLE GLASS or STORM WINDOWS	14	.52						84	.51	7. + 43. =	50.

SUMMER: Total Transmission & Solar Reduction = 57 - 50 = 7. BTU/(H) (SF)

WINTER: Total Transmission = (1.1 - .49) (52°F) = 32. BTU/(H) (SF)

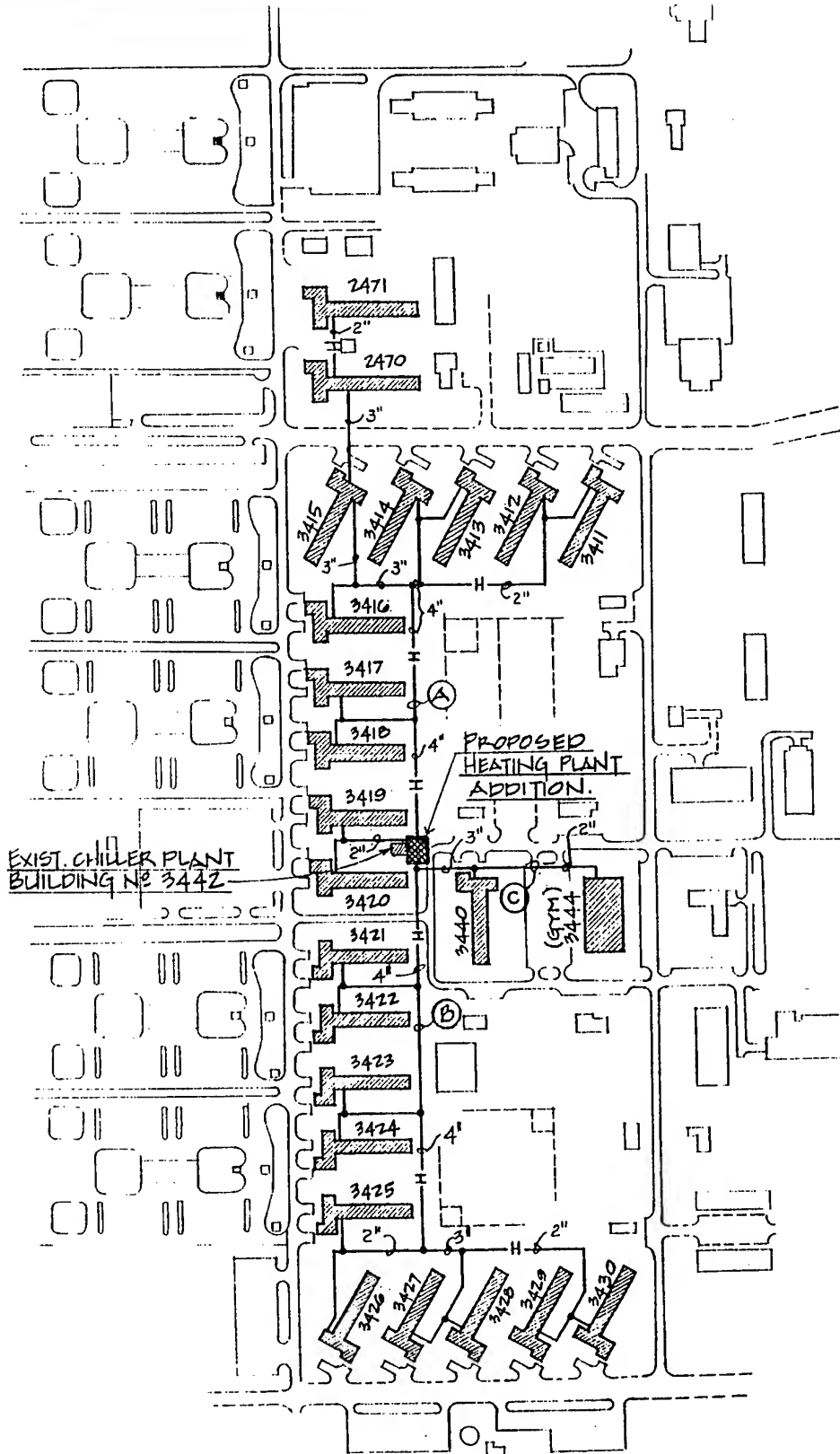
Total Reduction by adding Storm Windows including

Transmission, Solar, & Infiltration:

WINTER: 7.9 + 32. = 39.9 or 40. BTU/(H) (SF)

SUMMER: 2.9 + 7. = 9.9 or 10. BTU/(H) (SF)

SUBJECT Economic Analysis Back-Up		BY CRS		CHK 213
PREPARATION OF ENERGY CONTROL SYSTEM FOR FT SILL OK		DATE 17 Nov 79		REV
11 OF 13		FEDERAL CONTRACT NO DACAG3-77-C-0195		
PROJECT NO 1367		3442 G.H.P.		
Carnahan-Thompson-Delano, Inc.				

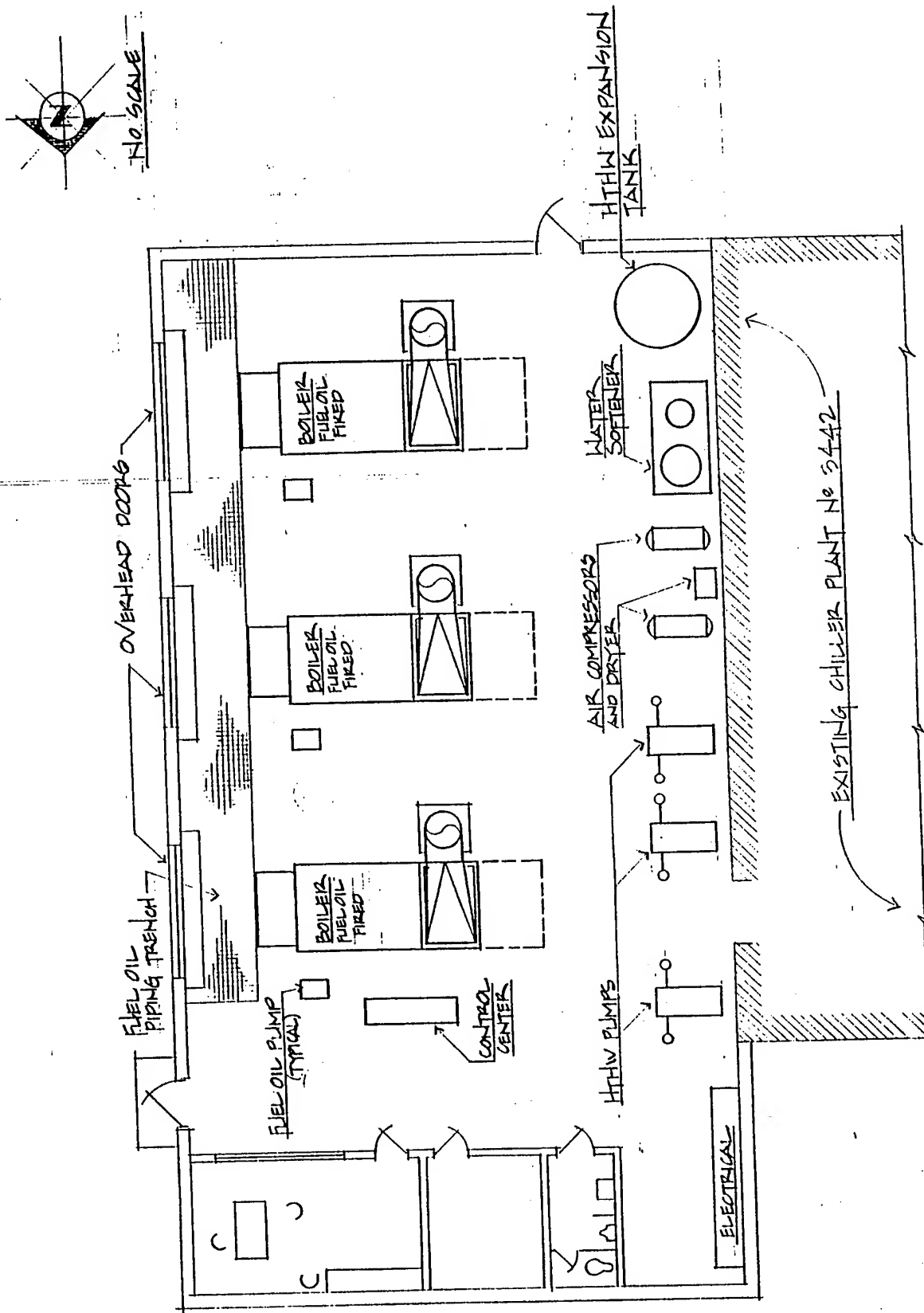


— H — HI-TEMP. HOT WATER SUPPLY AND RETURN LINES. (PROPOSED).

PLAN VIEW - NO SCALE

Arnahan-thompson-delano, inc. PROFESSIONAL CONSULTING ENGINEERS PROJECT NO. 1367 3442 C.H.P. FEDERAL CONTRACT NO. DACA63-77-C-0195	SUBJECT: <u>3400 AREA - CENTRAL HEATING PLANT</u>		12 OF 13
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK		
	BY: <u>C.R.S.</u> DATE: <u>5 MARCH, 1979</u>		
	CHK: <u>C.R.S.</u> DATE: _____ REV: <u>17 Nov. '79</u>		

FEDERAL CONTRACT NO DCA63-77-C-0195		CHK
PROJECT NO 1367		DATE
PREPARED BY		DATE
SUBJECT 3400 AREA - CENTRAL HEATING PLANT		DATE
BY CRG/RPB		DATE
PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL, OK		DATE
13		13



**APPENDIX H**

**RFD; 5900 CEP, DD1391**

AR 415-17: BUILDING COST INDEX 2158

1. DATE		2. FISCAL YEAR		3. MILITARY CONSTRUCTION PROJECT DATA				4. DEPARTMENT		5. INSTALLATION																	
19 Nov 1979		1982						Army		Fort Sill																	
5. PROPOSED AUTHORIZATION		6. PRIOR AUTHORIZATION		7. CATEGORY CODE NUMBER		8. PROGRAM ELEMENT NUMBER		9. STATE/COUNTRY																			
\$ 1,401,400.		P.L.		89045				Oklahoma																			
10. PROPOSED APPROPRIATION		11. BUDGET ACCOUNT NUMBER		12. PROJECT NUMBER		13. PROJECT TITLE		14. PROJECT TITLE																			
\$ 1,401,400.				B408-T498		Refuse Derived Fuel, 5900 C.E.P. (ECIP)		Refuse Derived Fuel, 5900 C.E.P. (ECIP)																			
SECTION A - DESCRIPTION OF PROJECT																											
14. TYPE OF CONSTRUCTION		15. PHYSICAL CHARACTERISTICS OF PRIMARY FACILITY																									
a. PERMANENT		X		b. NO. OF BLDGS		N/A		c. LENGTH		N/A																	
b. SEMI-PERMANENT				d. DESIGN CAPACITY		N/A		e. GROSS AREA		N/A																	
c. TEMPORARY				f. COOLING		CAP.		g. COST (\$)																			
16. TYPE OF WORK		17. DESCRIPTION OF WORK TO BE DONE																									
a. NEW FACILITY		Plant Bldg. #5900 to house refuse derived fuel boiler and ash & refuse handling equipment. Addition to be similar construction to existing Bldg. with concrete floors, ash pit, masonry walls, built-up roof on steel deck & structure. Site preparation work to include concrete, drives & ramps. Boiler; ram loader; conveyors; complete with controls & accessories with all electrical work, including loaders, piping & insulation.																									
b. ADDITION		X																									
c. ALTERATION																											
d. CONVERSION																											
e. OTHER (Specify)																											
18. REPLACEMENT																											
19. TYPE OF DESIGN		X																									
a. STANDARD DESIGN																											
b. SPECIAL DESIGN																											
c. DRAWING NO.																											
SECTION B - COST ESTIMATES																											
20. PRIMARY FACILITY		U/M		QUANTITY		UNIT COST		COST (\$2000)																			
a. Addition to #5900 C.E.P.		SF		7110		57.75		411																			
b. Solid Waste Boilers		Pa.		1		LS		663																			
c. Heating Water Pumps		Pa.		1		LS		3																			
d.																											
21. SUPPORTING FACILITIES																											
a. Refuse & Ash Handling Equip.						LS		324																			
b. Electrical						LS		153																			
c. Piping						LS		28																			
d. Site Work						LS		37																			
e. Controls						LS		9																			
f. Pollution Control Equip.						LS		88																			
g.																											
h.																											
i.																											
j.																											
22. TOTAL PROJECT COST										\$ 1,401.																	
SECTION C - BASIS OF REQUIREMENT																											
23. REQUIREMENT FOR PROJECT This project is required to offset energy generated by existing boilers in the #5900 C.E.P. facility, thus reducing fuel-oil consumption, substantially. Present refuse hauling for Ft. Sill will be decreased by diverting same to C.E.P. where combustibles will be partially separated for incineration in boiler specifically designed for such. Refuse & ash handling facilities, including additional operators will be required. The natural environment will be greatly improved by reducing land-fill requirements from 45 tons/day to 12.6 tons/day, or 72%. This project has been reviewed and it has been determined that an "environment impact statement" pursuant to P.L. 91-190 is not required. This project will realize the following annual savings:																											
<table border="0"> <tr> <td>MONETARY:</td> <td>\$529,627.</td> <td>TOTAL ENERGY:</td> <td>139,547. MBTU</td> </tr> <tr> <td>AMORTIZATION PERIOD:</td> <td>2.7 Years</td> <td>ELECTRICITY:</td> <td>(-)98,024. KWH</td> </tr> <tr> <td>SAVINGS PER \$1000</td> <td>(C)</td> <td>FUEL-OIL:</td> <td>1,012,300. Gal.</td> </tr> <tr> <td>BENEFIT/COST RATIO:</td> <td>8.2</td> <td></td> <td></td> </tr> </table>												MONETARY:	\$529,627.	TOTAL ENERGY:	139,547. MBTU	AMORTIZATION PERIOD:	2.7 Years	ELECTRICITY:	(-)98,024. KWH	SAVINGS PER \$1000	(C)	FUEL-OIL:	1,012,300. Gal.	BENEFIT/COST RATIO:	8.2		
MONETARY:	\$529,627.	TOTAL ENERGY:	139,547. MBTU																								
AMORTIZATION PERIOD:	2.7 Years	ELECTRICITY:	(-)98,024. KWH																								
SAVINGS PER \$1000	(C)	FUEL-OIL:	1,012,300. Gal.																								
BENEFIT/COST RATIO:	8.2																										
24. RELATED PROJECTS																											

DD FORM 1391  
3 OCT 73

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Page No. 1

19 Nov 1979

Fort Sill

Refuse Derived Fuel - 5900 C.E.P.

Project No. B408-T498

1. GENERAL. This project is needed to conserve fuel in an existing, permanent facility. Refuse collected amounts to 45 to 50 tons per day; and approximately 80% is combustible and heat can be reclaimed through incineration type boiler. This method can substantially reduce the energy now consumed with fuel-oil type boilers in an existing Central Plant.

2. ACCOMMODATIONS NOW IN USE.

Permanent Central Energy Plant #5900, 5750 S.F.

3. ANALYSIS OF DEFICIENCY. The existing Central Energy Plant is designed and used for fuel-oil fired boilers. New refuse derived fuel boiler will require addition to structure for refuse storage and handling.

4. CONSIDERATION OF ALTERNATE FACILITIES.

Not applicable.

5. CRITERIA FOR PROPOSED CONSTRUCTION. Scope of this project is to add to existing Building #5900 plant in similar construction, but with accommodation for one incinerator type boiler and accessories. This project to be coordinated with proposed coal-fired boiler plant addition #B408-T493.

6. PROGRAM FOR RELATED FURNISHINGS AND EQUIPMENT. Equipment intended for installation is to be procured with a portion of the total funds requested.

7. DISPOSAL OF PRESENT ASSETS. There will be no disposal of present assets as a result of this project.

8. SURVIVAL MEASURES.

Not applicable.

9. SUMMARY OF ENVIRONMENTAL CONSEQUENCES. This project has been reviewed and will not contribute significantly to air and water pollution.

10. EVALUATION OF FLOOD HAZARD. This project is an addition to an existing facility and is not in an area known to be subject to flooding.

11. ECONOMIC SAVINGS. An economic analysis is attached herewith.

12. UTILITIES SUPPORT. Adequate utilities support is available for this project. Connections to existing utilities will be required.

13. PROTECTION OF CULTURAL ENVIRONMENT. This project has no impact on any designated historical place.

14. PROJECT DEVELOPMENT BROCHURE. A Project Development Brochure has been prepared for this project.

15. ENERGY REQUIREMENTS.

a. Project Description. A 7110 S.F. addition to Bldg. #5900 Central Energy Plant, for housing one incinerator type boiler.

b. Estimated Energy Uses.

(1). The Central Plant addition will be heated by H.W. unit heaters connected to existing systems.

(2). No air conditioning required by this project.

(3). No hot water services required by this project.

(4). Electric power will be required for lighting and power equipment.

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19 Nov 1979

Fort Sill

Refuse Derived Fuel - 5900 C.E.P.

Project No. B408-T498

(5). Sewerage Systems. Sewerage connections to existing facility will be required for building addition.

c. Energy Sources.

(1). Refuse is collected daily and will be delivered to this proposed facility in lieu of being hauled an extra three miles to a land-fill.

(2). Electric Power is from existing C.E.P. Present system is adequate for requirements for this project.

(3). Water Supply is provided by the City of Lawton to existing facility. Present capacity is adequate for this proposed project.

(4). Sewerage System is Government owned and is adequate to accommodate this proposed facility.

d. Energy Use Impacts. Significant favorable impacts will result from burning refuse collected from Fort Sill. Land-fill requirements will be reduced over 70% and slight decrease in hauling expense will be realized.

e. Energy Reduction. A reduction in source energy will occur with this project. Present fuel-oil fired boilers would be displaced, thus saving energy and prolonging the life of present equipment.

f. Energy Alternatives. This is a modification project to existing systems, therefore, energy alternatives are not applicable.

g. Energy Efforts. The energy system to be utilized in this system will have a favorable impact on the present environment.

h. Basis of Appraisal. The basis for utilizing refuse for incineration in boilers is a practical approach for disposing of such wastes and at the same time decrease the necessity for relying on fossil fuel.

16. PROVISIONS FOR THE HANDICAPPED. In accordance with P.L. 90-480, no provisions for the handicapped will be made in the project since the facility will be used and operated solely by able bodied personnel.

*Jack L. Van Pool*  
JACK L. VAN POOL  
Colonel, FA

Deputy Installation Commander

# BUDGETARY ESTIMATED DATA

Anticipated Construction Start Date: Apr 1982  
 Anticipated Construction Completion Date: Apr 1983  
 Anticipated Midpoint of Construction Date: Oct 1982  
 Construction Cost Index for Anticipated Midpoint of Construction Date: 2158

Fort Sill, Oklahoma FY 1982 19 Nov 1979  
 Project No. B408-T498  
 Description: Refuse Derived Fuel - 5900 C.E.P. (ECIP)

	Quantity	Unit	Unit Cost	Total (\$000)
1. Primary Facility				
a. Addition to 5900 C.E.P. Bldg. (\$46/SF x 2158 + 1719 = 57.75)	7110.	SF	57.75	411.
b. Solid Waste Boiler & Accessories	1	Ea.	LS	663.
c. HTHW Pump	1	Ea.	LS	3.
2. Supporting Facility				
a. Refuse and Ash Handling Equipment: (Conveyors, Hoppers, Front-end Loaders)			LS	153.
b. Electrical Power & Lighting			LS	9.
c. Piping & Insulation (Incl. Water, Sewerage) Fuel Oil Piping			LS	26.
d. Site Work Paving			LS	2.
e. Controls Meters & Instruments			LS	14.
f. Pollution Control Equipment & Misc.			LS	23.
			LS	2.
			LS	7.
			LS	88.
TOTAL ESTIMATED COST				1,401.

# ECONOMIC ANALYSIS (ECIP)

Location: Fort Sill, Oklahoma FY 1982  
 Project: Refuse Derived Fuel - 5900 C.E.P.  
Project No. B408-T498  
 Economic Life 25 Yrs. Date Prepared 19 Nov 1979 Prepared By C. Robert Scruggs

## COSTS

### 1. Non-recurring Initial Capital Costs.

a. CWE	\$ 1,401,400.
b. Design	\$ 75,547.
c. Salvage	\$ -
d. Total	\$ 1,476,947.

## BENEFITS

### 2. Recurring Benefit/Cost Differential Other Than Energy

a. Annual Labor Decrease (+)/ Increase (-)	\$ 139,719. /Yr. (-)
b. Annual Material Decrease (+)/ Increase (-)	\$ - /Yr.
c. Other Annual Decrease (+) /Increase (-)	\$ - /Yr.
d. Total Costs	\$ 139,719. /Yr. (-)
e. 10% Discount Factor	9.524
f. Discounted Recurring Cost (d x e)	\$ 1,330,684. (-)

### 3. Recurring Energy Benefit/Costs

#### a. Type of Fuel Electricity

(1) Annual Energy Decrease (+)/ Increase (-)	853. MBTU (-)
(2) Cost per MBTU	\$ 2.07 /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	\$ 1,766. /Yr. (-)
(4) Differential Escalation Rate ( 7 %) Factor	18.049
(5) Discounted Dollar Decrease/Increase ((3)x(4))	\$ 31,875. (-)

#### b. Type of Fuel Electric Demand

(1) Annual Energy Decrease (+)/ Increase (-)	N/A MBTU
(2) Cost per MBTU	\$ - /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	\$ - /Yr.
(4) Differential Escalation Rate ( 7 %) Factor	-
(5) Discounted Dollar Decrease/Increase ((3)x(4))	\$ -

#### c. Type of Fuel Fuel Oil

(1) Annual Energy Decrease (+)/ Increase (-)	140,400. MBTU (+)
(2) Cost per MBTU	\$ 4.78 MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	\$ 671,112. /Yr. (+)
(4) Differential Escalation Rate ( 8 %) Factor	20.050
(5) Discounted Dollar Decrease/Increase ((3)x(4))	\$ 13,455,796. (+)

#### d. Type of Fuel

(1) Annual Energy Decrease (+)/ Increase (-)	MBTU
(2) Cost per MBTU	\$ - MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	\$ - /Yr.
(4) Differential Escalation Rate ( % )	-
(5) Discounted Dollar Decrease/Increase ((3)x(4))	\$ -

e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	\$13,423,921.
---	---------------

4. Total Benefits (Sum 2.f + 3e)	\$12,093,237.
----------------------------------	---------------

5. Discounted Benefit/Cost Ratio (Line 4 ÷ Line 1d)	8.2
---	-----

6. Total Annual Energy Savings 3a(1)+3b(1)+3c(1)+3d(1)	139,547. MBTU
--	---------------

7. E/C Ratio (Line 6 ÷ (Line 1a/1,000))	99.6
---	------

8. Annual \$ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3))	\$ 529,627.
---	-------------

9. Payback Period ((Line 1a - Salvage) ÷ Line 8)	2.7 YEARS
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# ECONOMIC ANALYSIS (CONT.)

## 1. Non-recurring Initial Capital Costs:

### Construction

SIOW @ 5 %

Unescalated CWE

CWE (Escalated to End FY 82):

$\$1094503 \times 1.07 \times 1.065 \times 1.06 \times 1.06$

(Entered on Line 1.a.)

Unescalated Design @ 6 % of Construction:

$.06 \times \$1,042,384.$

Design (Escalated to End FY 81):

$\$62,543 \times 1.07 \times 1.065 \times 1.06 \times$

(Entered on Line 1.b.)

Salvaged value of removed equipment:

Salvage value (Escalated to End FY 82):

$\$ \times 1.064 \times 1.062 \times 1.056 \times 1.056$

(Entered on Line 1.c.)

## 2. Recurring Benefit (+)/Cost (-) Differential Other Than Energy:

Labor (Unescalated)

Labor (Escalated to End FY 82)

$\$110882 \times 1.064 \times 1.062 \times 1.056 \times 1.056$

(Entered on Line 2.a.)

Materials (Unescalated)

Materials (Escalated to End FY 82):

$\$ \times 1.064 \times 1.062 \times 1.056 \times 1.056$

(Entered on Line 2.b.)

## 3. Recurring Energy Benefits (+)/Costs (-):

### a. Electric Energy: ((-)98024KWH x 8700 BTU/KWH)

MBTU Saved

(Entered on Line 3.a.(1).)

\$ Cost/MBTU

\$ Cost/MBTU (Escalated to End FY 82):

$\$1.207 \times 1.16 \times 1.16 \times 1.13 \times 1.13$

(Entered on Line 3.a.(2).)

### b. Demand Charge Reduction:

MBTU Saved:

Negligible

Annual Dollar Saving

Annual Dollar Saving (Escalated to End FY 82):

$\$ \times 1.16 \times 1.16 \times 1.13 \times 1.13$

(Entered on Line 3.b.(3).)

### c. Distillate Fuel Oil: (1012300 Gallons x 138,700 BTU/GAL.)

MBTU Saved

(Entered on Line 3.c.(1).)

\$ Cost/MBTU

\$ Cost/MBTU (Escalated to End FY 82):

$\$2.732 \times 1.16 \times 1.16 \times 1.14 \times 1.14$

(Entered on Line 3.c.(2).)

ABBREVIATIONS

DENOTATION

K	KILO (10 <sup>3</sup> )
M	MEGA (10 <sup>6</sup> )
KBH	1000 BTU/HR.
MBH	MEGA BTU/HR.
MBTU/YR. (or MBU/YR)	MEGA BTU/YEAR
CF	CUBIC FEET
GAL	GALLON
KWH	KILO WATT-HOURS

FUEL	COST OF FUEL		REMARKS
	@ FT. SILL	@ SOURCE	
NATURAL GAS (JAN '78)	\$1.305/KCF	\$1.231/MBU	RE: ARKLA GAS COMPANY @ 1060 BTU/CF.
FUEL OIL #2 (JUL '78)	\$0.3789/GAL	\$2.732/MBU	RE: KERR-McGEE COMPANY #1 DISTIL. F.O. @ 138,700 BTU/GAL.
COAL (APR '78)	\$40.75/TON	\$1.658/MBU	RE: ASSOCIATED PRODUCERS COMPANY @ 13,478 BTU/LB OR 26,956 MBU/TON *1 USE: 24.58 MBU/TON
<u>ELECTRICITY</u> (SEPT '78)			RE: PUBLIC SERVICE CO. OF OKLA. & SWPA 25% HYDRO-ELEC. @ \$0.002/KWH TO 4.877 MKWH + \$0.003/KWH ALL OVER 4.877 MKWH.
ENERGY CHARGES			75% FOSSIL FUEL @ \$0.01338/KWH: 25% @ \$0.002 = \$0.0005 75% @ \$0.01338 = \$0.0100 \$0.0105/KWH
	\$0.0105/KWH		\$0.0105/KWH (75% x 11,600 BTU/KWH #2) + (25% x 0 BTU/KWH (HYDRO-ELEC.) = \$0.0105 x 8700 = \$1.207/MBU (@ SOURCE)
		\$1.207/MBU	FROM 8700 BTU/KWH TO 3414 BTU/KWH (@ FT. SILL): 2.548 x \$1.207 = \$3.076/MBU (@ FT. SILL)
DEMAND CHARGES			RE: PUBLIC SERVICE CO. OF OKLA. MINIMUM MONTHLY CHARGE BASED ON 32,500 KW x \$1.60 = \$52,000
	\$1.60/KW		

\*1 RE: ECIP

\*2 For this report, we have taken the recommended 11,600 BTU/KWH as given by the ECIP Guidance (DAEN-FEU, 7-Nov. 1977) for Source Energy and derated it 25% or 8700 BTU/KWH because of the advantages Ft. Sill is receiving from hydroelectric generation.

<b>carnahan-thompson-delano, inc.</b> professional consulting engineers PROJECT NO. 1367 RDF-5900 CEP FEDERAL CONTRACT NO. DAC481-77-C-0195	SUBJECT	FUEL CHARGES-ENERGY COST-LEGEND	1 OF 6			
	PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL, OK					
	BY	CRS-JHG-PRMc				
	DATE	23 Feb '79				
	CHKD	CRS	DATE	29 Jun 79	REV	

# ECONOMIC ANALYSIS BACK-UP

FY PROGRAM	INSTALLED BOILER CAPACITIES	CAPACITIES	
		LOAD MBH	TOTAL CONNECTED MBH
'79 (Existing)	2 @ 9.8 MBH	19.464	19.464
'80	Add 2-15. MBH *1	22.369	41.833
'81	Add 2-15. MBH *1	16.434	58.267
'82	-	-0-	58.267

Add 1 new RDF Boiler w/Fuel-oil standby.  
Capacity of Boiler based upon following:

1. Total Refuse Collected = 45 to 50 Tons/Day
2. Collecting & Hauling Costs (1 May '77 thru 30 Apr. '78) = \$375,452.

Basis of Study: \*2

1. Weight of Refuse = 600 #/yd<sup>3</sup>
2. Class I Rubbish Consisting of:

a. Combustible Waste: 80%  
Paper, rags, woodscraps, combustible  
floor sweepings, domestic, commercial  
& industrial sources

b. Garbage = 20%  
(Moisture Content of Garbage = 25%)  
(Non-Combustible Solids of Above = 10%)

3. BTU Value of Refuse as Fired. = 6,500 BTU/#

BTU of Auxiliary Fuel Not in Calculations

4. Total #/Day = 45 Tons X 80% (Combust. Refuse)  
X 2,000 #/Ton = 72,000 #/Day

Total BTU/Day = 72,000 #/Day X 6,500 BTU/# = 468 MBTU/Day

Hourly Value =  $\frac{468 \text{ MBTU/Day}}{24 \text{ Hrs/Day}}$  = 19.50 MBH

$\frac{19.50 \text{ MBH} \times 3}{6,500 \text{ BTU/#}}$  = 3,000 #

Try: Basic Solid Waste Boiler Model #3000-B  
@ 24 MBTU/Hr input @ 70% Efficiency = 16.8 MBH

5. Total Energy Estimated Per Year From RDF:

E = 468 MBTU/Day X 300 (Pick-up) Days/Year = 140,400. MBTU/Yr  
(Total Input RDF)

1-Fuel-oil Fired Boiler (Exist'g FY'80) = 15 MBH

$\frac{15 \text{ MBH}}{.70(\text{eff.})} \times 24 \text{ Hrs} \times 300 \text{ Days/Yr} = 154,286 \text{ MBTU/Yr}$   
(Total Input F.O.)

\*3 Re: International Boiler Works Co. & Basic Environmental  
Engineer'g Co.

\*2 Re: Basic Environmental Engineer'g Co.

\*1 Re: Wilson & Co. Study of 6000 Area Programming.

<p><b>Carnahan-Thompson-Delano, Inc.</b> PROJECT NO. 1367 RDF-5900 CEP</p>	<p>SUBJECT: Economic Analysis Back-up PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL, OK BY CRS DATE: 19 Nov 79</p>	<p>2 OF 6</p>
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"A" Assume Energy from 1 Fuel-oil Boiler Saved with 1-#3000-B RDF Boiler or

140,400 MBTU/Yr  
(Min. Saved)

"B" Annual Costs/Benefits:

\$ Per Year  
Saved (+) Cost (-)

1. Refuse Contract Reduction:

100% Refuse collected & hauled to RDF site in lieu of Dump = 45 Tons  
20% Non-Combustibles = 9 Tons  
80% Combustibles = 36 Tons  
10% Ashes = 3.6 Tons

To Sanitation-Fill = 12.6 Tons

Assume contract reduction to be based on following:

- a. 6 mile round-trip to dump site (in lieu of 13 miles) say 50% reduction.
- b. Sanitation fill charges reduced (12.6 Tons / 45 Tons) to 28%  
Estimate Sanitation Contract Reduction @ 15% X \$375,452 = \$56,318.
2. Additional operators & laborers to handle RDF equipment, separation & maintenance on 24 hr. basis:  
2 men X 24 hrs X 365 days/yr X \$10/hr = \$175,200.
3. Assume vehicle costs & energy usage for RDF handling to be offset with truck hauling to dump site. -0-
4. Extended life of 1 Fuel-oil boiler and accessories not in use (during RDF firing):  
1 Boiler, pump & accy's = \$200,000/25 yrs = 8,000.

TOTALS

= \$64,318. \$175,200.

Net recurring costs

\$110,882. (-)

"C" Energy expended w/RDF plant as compared to Fuel-oil boiler.

Forced Draft Blower motor

10 Hp

After-Burner Blower motor

5 Hp

Misc. Motors: Powered plug ash remover, plug spreader feeder, bomb bay doors, ash conveyor, non-combustible conveyors, induced draft blower, etc.

10 Hp + (w/diversity)

TOTAL

25 Hp +

LESS: Conventional Fuel-oil Boiler Blower

Motor (-) 10 Hp

NET ESTIMATED ADDITIONAL

15 Hp +

Assume:

E (Elec'l) = 15 Hp X 0.746 Kw/Hp X 24 Hrs/Day X 365 Days/Yr

E (Elec'l) = 98,024 Kwh/Yr additional

Carnahan-Thompson-DeLano, Inc.

SUBJECT Economic Analysis Back-up

PREPARATION OF ENERGY CONTROL SYSTEM FOR

BY CRS

DATE 19 Nov 79

OF

6

$\Sigma$  COSTS/SAVINGS PER YEAR

METHOD	TOTAL SOURCE MBTU	TOTAL FUEL SAVED		RECURRING COSTS	DESCRIPTION OF COSTS/ SAVINGS METHOD
		ELECTRIC KWH	#2 OIL MBTU		
"A"	140,400.	-	140,400.	-	Fuel oil saved
"B"	-	-	-	(-) \$110,882.	Recurring costs
"C"	(-) 853.	(-) 98,024.	-	-	Electric Energy expended
TOTALS	139,547	(-) 98,024.	140,400.	(-) \$110,882.	
		((-) 853. MBTU/Yr)	(1,012,300. Gal)		

Carnahan-Thompson-Delano, Inc.  
PROJECT NO. 1202 RDP-5900 CEP

SUBJECT Economic Analysis Back-up  
PREPARATION OF ENERGY CONTROL SYSTEM FOR FT. SILL. OK  
BY CRS DATE 19 Nov 79

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OF  
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